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Ship Designer's Handbook

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SHIP DESIGNERS HANDBOOK

FOR

NATIONAL SHIPBUILDING RESEARCH PROGRAM

Product Design and Materials Technologies Panel

Produced by:

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NSRP Project No. 6-96-1

Bath Iron Works
A GENERAL DYNAMICS COMPANY

EXECUTIVE SUMMARY

Becoming more competitive in the international shipbuilding marketplace is a high priority goal for the U.S. shipbuilding industry. Achieving this objective requires in-depth knowledge of both foreign and domestic design practices, shipbuilding rules, and shipping regulations.

Most American ship designers are familiar with the American Bureau of Shipping (ABS) construction rules. ABS is part of the community of major international classification societies, including Lloyd's Register (LR), Det Norske Veritas (DNV), Nippon Kaiji Kyokai (NK), and Germanischer Lloyd (GL). To gain and maintain an internationally competitive position, U.S. shipbuilders must be capable of understanding and applying the requirements of this diverse group of classification societies.

This project provides a database that will help American ship designers distinguish the similarities and differences between ABS's requirements and those of other internationally prominent societies. To do this in the most effective and efficient manner, the problem was approached from both a qualitative and a quantitative direction.

The qualitative treatment is a U.S. Navy Ship Work Breakdown Structure (SWBS)-based index of ship construction rules for four classification societies (ABS, LR, DNV, and NK). SWBS Groups 100 through 600 were included. This information is presented in a concise manner by the Microsoft Excel spreadsheet titled, "Qualitative SWBS Analysis Database" that accompanies this report and includes a "significant differences" field with other important observations made during rule assessment.

In the course of compiling this information, it became apparent that few instances of significant difference could be found. The International Association of Classification Societies (IACS), has adopted the "Unified Requirements", which, among other things, specifies minimum longitudinal hull girder strength requirements. Applying this uniform standard for longitudinal strength has the effect of minimizing any resulting differences between societies for the major portion of a ship's structure (SWBS Group 100). Many other topics covered by class rules are mandated by the IMO Conventions, and hence similar for all societies.

The quantitative treatment develops and compares the midship section scantlings for two container ships of modern design. The scantlings for both designs were generated by applying the minimum scantling rules of three classification societies (ABS, DNV, and GL). The designs used are NASSCO's R.J. PFEIFFER, a conventional, Panamax ship that was delivered to Matson Lines in 1992, and BIW/Kvaerner's BATHMAX 1500, a high-speed vessel with a slender, wave-piercing hull.

The results are tabulated along with the "as designed" (BATHMAX 1500) or "as built" (R.J. PFEIFFER) scantlings for the various plates and stiffeners that form the longitudinally continuous material at the midship section. The key finding from this part of the exercise is that longitudinal strength and fatigue requirements must take precedence over the rules for local structure.

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1.0 INTRODUCTION

This work was performed under NSRP Project Number 6-96-1, Ship Designer's Handbook – Cross-Reference of Requirements". Originally, NSRP's SP-6 panel (Marine Industry Standards) monitored the project. Over time and through reorganization, project responsibility has been passed to NSRP's SP-14 team (Product Design and Materials Technologies Major Initiative).

Since the project's original inception, developments and changes within the marine industry have shifted the project's focus to a product that will help to solve current problems and anticipate future demands. Nevertheless, the motivation for performing the work has remained unchanged: To improve the competitive position of the U.S. shipbuilding industry in the international marketplace.

Building the knowledge and capability base of the U.S. shipbuilding industry is the goal of the NSRP. Developing more informed and educated people does indeed assist in helping the U.S. become competitive in the world market, but it also has benefits to advance the industry domestically. To produce products that will receive acceptance in the international market requires knowledge of the international rules and regulations. Regulations are standardized by the various International Maritime Organization (IMO) conventions, but the rules of the various individual classification societies present a very different problem. The design group at a U.S. firm needs the capability to recognize major differences between their standard practices and those that are required to meet the rules of an unfamiliar classification society. This early recognition reduces time to acclimate a designer to a new society's rules. Familiarity with foreign classification societies will also fuel inventive thinking, intelligent debate, and new innovations by U.S. ship designers.

Bath Iron Works, through Newport News Shipbuilding, began this NSRP project in May 2000 and concluded it at the end of October 2000. The work was divided into two tasks:

- The first task is a qualitative analysis, indexed by U.S. Navy SWBS number, that compares the provisions of four societies' rules (ABS, DNV, LR, NK).

- The second task undertakes the assessment of rule differences in a quantitative fashion; a comparison of the effects on midship section structural scantlings due to applying three societies' rules (ABS, DNV, GL) was conducted

The key results of the analysis were:

- Building a comparison database
- Providing the comparison tool to industry
- Gaining familiarity with commercial standards.

This project's final deliverables consist of this handbook, its appendix, and a Microsoft Excel spreadsheet file in electronic format. The handbook is organized as follows:

- Introductory information with regard to the use and development of the handbook

- Details of the processes, methods, and formats used to develop the electronic database

- Discussion of the results, which includes a description of the electronic deliverable along with the overall observations of any trends and particular conclusions

- Recommendations, which are followed by the references and appendix

2.0 SUMMARY of FINDINGS

A list of findings from the analysis follows:

- Primary scantlings are driven by longitudinal bending criteria
- A shift to FEA and first principles analysis/design is taking precedence over prescribed equations from rulebooks.
- The structural design of a new vessel is a complex, iterative, time-consuming process that is best undertaken by competent people with the latest tools and analysis programs.
- The rules and rulebooks primarily can only provide a building block for structural scantlings.
- The IACS has considerable influence on the structural aspect of designs, and on the society rules themselves. Unified Requirements have led to global minimums for longitudinal strength, which is the basis for the structural design as a whole.
- IMO and flag state regulations have major influence on non-structural topics of ship design, including operations. The classification societies develop their rules to meet these regulations directly in many cases, leading to more similarity between societies.
- The need for more ships for "significant" conclusions in scantling analysis was discovered. Concrete trends and conclusions cannot be confidently made. However, comparisons between societies for the same ship can be made.
- Electronic software programs are becoming very important and in some cases mandatory for structural design approval. These include programs published from classification societies and non-society programs.
- Investment in new tools for designers is imperative. However, companies and individuals need to recognize the need to invest in upkeep and training of the software and skills to operate the software efficiently as well.
- The United States does not have a universally accepted Work Breakdown Structure for commercial design. The Navy SWBS is not an acceptable substitute for world-class work breakdown structures. The U.S. needs to adopt a foreign system or develop its own, slanted toward U.S. practice.
- Societies have understood reciprocal agreements to accept another society's rules and approvals as their own whenever necessary.

3.0 PROJECT BACKGROUND

The current transition from traditional DOD to commercial specifications in design and construction among U.S. Shipbuilders and the U.S. Navy has generated new thinking as well as, a great deal of energy as the industry strives to reduce cost and become competitive in the global market.

The marine industry knows that compliance with international regulatory body requirements and a familiarization with foreign class society rules are keys to becoming

competitive. The Government has also realized that over-regulation is a hindrance to competitive pricing. Part of this realization has been the development of such programs as the USCG Alternate Compliance Program (ACP), which is one part of reducing the high costs of building a U.S. flagged vessel. The ACP allows the class society, namely ABS in the United States, to be responsible for the plan review and approval for all aspects, which include class rules, Coast Guard regulations, and International regulations. The class societies have also taken on more responsibility for incorporating such regulations right into the rules from the beginning, this allows for many International regulations, such as SOLAS, to be satisfied without necessarily consulting the SOLAS text in many instances. We predict further development and cooperation between class societies, IMO, and the USCG to make the process much more streamlined for designers, flag state officials, and class surveyors all together.

The project brings together the different class societies in a manner that can provide a focus and a base for future development of other projects. Continuing the recent trend in industry collaboration and uniformity, the International Association of Classification Societies (IACS), has made major strides in standardizing major components of structure and safety between all its members. All major world class societies are members of IACS. As time continues, further standardization, collaboration, and unification will provide an even more solid basis for which the quality, safety, and upkeep of the world's merchant fleet can grow and still maintain its integrity. This will surely benefit the U.S. shipbuilding industry as well.

The initial BIW proposal submitted on 27 March 2000 to the panel included the scope to compile a listing and indexing of various publications, namely classification societies. This scope would have produced a searchable index of document references organized by SWBS number. After this proposal was submitted and accepted, but before work commenced on this project, it was discovered through initial research that this exercise had been completed as a separate project (latest revision – NSRP 0488). With this new information, the project's scope shifted to this comparison and analysis of classification societies.

4.0 OBJECTIVES

This project's overall objectives are to provide:

- Concise, organized information on the similarities and differences between the ship design rules of various classification societies
- Increased familiarity with international classification societies for U.S. owners, designers, engineers, and students
- Savings in design time and effort due to early recognition of major discrepancies between known practices and required results
- A top-level reference tool to assist ship owners and their design staff in classification society assessment and selection
- Insight to the present day relationships between the ship designer, classification society, and the process by which a design advances through the approval cycle

Considering the overall goals and objectives, it was decided that the work objective and end product would be: to develop a top-level handbook/tool, through educated technical assessments of classification society rules, for owners, designers, engineers, and students, that will assist their efforts to assess the impact of various classification societies on ship design features.

To accomplish these goals, the categorization needed to be familiar to designers and engineers. The U. S. Navy's Ship Work Breakdown Structure (SWBS) is the standard U.S. practice for a work breakdown structure at many U. S. shipyards. This led to having the index organized by SWBS number.

5.0 TECHNICAL APPROACH

5.1 Scope Summary

Due to the difference in the timeframe from the original abstract and today, the project's scope took on a new direction, with the approval of the NSRP Product Design and Material Technologies Panel. This change in direction resulted in a revised scope of work to be completed for the project.

To provide a top-level initial reference tool for designers, owners, and operators requires an in-depth analysis and technical assessment of the various sections, rules and topics covered within the society rules. It was determined that only the main class rules for construction of steel ships would be used for the qualitative analysis. This excludes special analysis of differences in rules between type-specific vessels such as vessels intended to carry oil in bulk.

Also, due to the lack of perceived complexity in developing new and separate midship sections for different vessels, the quantitative analysis' scope was narrowed to three classification societies along with the as-built or as-designed scantlings. Germanischer Lloyd was inserted due to the structural development software made available to the project. DNV was retained due to the position enjoyed as a technological leader in rules, keeping up to speed with fast changing developments in various aspects of machinery and design. ABS was included as the standard for U.S. design and construction.

5.2 Procurement of Publications

It was necessary to procure the various publications and software from the class societies. Publications and software from eight sources were obtained. These included class societies and regulatory body publications.

5.3 Qualitative Analysis

In response to the original solicitation's suggestion, SWBS was chosen as the indexing basis as it is the most familiar breakdown structure in the United States today. The U.S. Navy SWBS provides the basic systems and parts necessary to complete the most basic analysis. However, as the project progressed, and the analysis progressed through the rules, it was realized that SWBS had significant flaws for providing a strong breakdown structure for commercial based ships and designs. This is discussed later in the report. It was also decided to only concentrate on SWBS Groups 100 through 600. The other groups are not applicable to commercial design and/or do not directly relate to design efforts, but rather construction, administration, and/or operations.

Using the SWBS designation as the indexing basis, the first step in going through the rulebooks was to align the section/rule/part in the book to the appropriate SWBS

number. For a number of SWBS numbers, there were many sub-items that could be classified under that one SWBS number. In the database, for those cases, there are multiple rows for the same SWBS. The sub-topic's designation is made under the "Description" cell.

The entire rule text or equation is not included in the database due to copyright considerations. Items that are included in the database, where applicable, include the variables (type and total number), but not the actual equation.

Once all similar rules within the societies were assembled, a technical assessment of the rule was made. Any significant differences, major similarities, and notes of interest were then entered into the database.

5.4 Quantitative Analysis

The present work seeks to furnish the ship owner/designer with a computer-based tool capable of providing some familiarity with the similarities and differences between the classification society rules. To amplify those points in a quantitative manner, midship section scantlings were developed for two commercial ship designs based on the rule minimum scantlings of three classification societies.

5.4.1 Design Process

The structural design process for a commercial ship consists of a series of tasks:

- Develop an initial set of scantlings based on a structural configuration, the longitudinal bending moment, and the selected classification society rules
- Apply seakeeping analysis to determine the environmental loads
- Use global and local finite element analysis to verify the design's strength and refine the configuration and scantlings
- Perform spectral fatigue analysis of specific structural assemblies and components to finalize the configuration and scantlings

5.4.2 Design Tools

The major classification societies have invested significant resources in the development of computer-based tools for the ship design community that automate and integrate the entire design process:

- ABS - SafeHull
- LR - ShipRight
- DNV - Nauticus Hull
- GL - Poseidon ND
- NK - PrimeShip

Such programs apply the rule requirements in a comprehensive and consistent manner with continuous transfer of design information between successive steps in the process. BIW obtained a copy of Poseidon ND plus a tutorial on its use from Germanischer Lloyd to use on the quantitative work to be performed. In addition, scantlings were also developed to comply with the ABS and DNV rules. A spreadsheet for scantling

generation according to the DNV rules was created, and a similar spreadsheet was created to apply the ABS rules.

5.4.3 Designs

The ship designs selected are both container ships of equivalent size (abt. 1,500 TEU):

- BathMax 1500 - a high speed, twin-screw design concept with a slender, wave-piercing hull form, shown in Figure 5.1
- R. J. Pfeiffer - a single screw, Panamax design delivered to Matson Lines by NASSCO in 1992, shown in Figure 5.2.

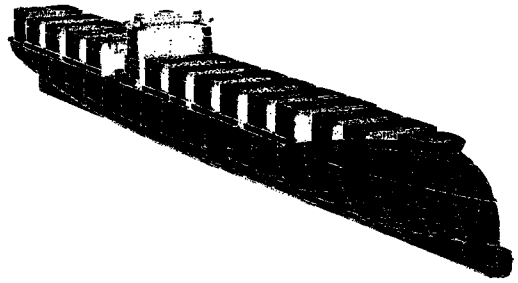


Figure 5.1: BIW/KMM BathMax 1500

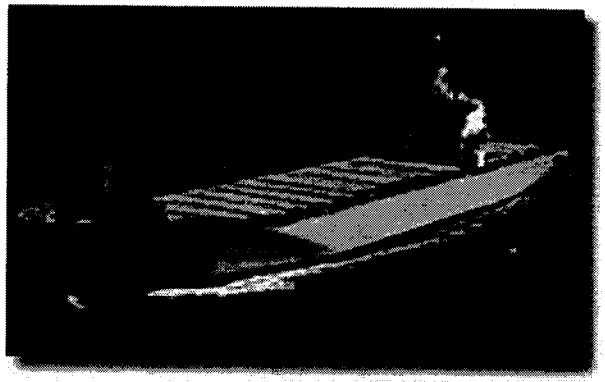


Figure 5.2: NASSCO-built Matson R.J. Pfeiffer

Item	BATHMAX 1500	R J Pfeiffer
LWL	248.37 m	207.81 m
LBP	247.80 m	205.16 m
Beam	27.50 m	32.21 m
Depth	17.40 m	20.27 m
Draft	9.00 m	11.58 m
Block Coefficient	0.431	0.557
Maximum Speed	33.2 kts	23.5 kts

Table 5.1: Ship Particulars

These particular designs were chosen for inclusion in this study because of the timely availability of the structural plans and supporting calculations. Table 5.1 tabulates the principal particulars for both designs.

The as-designed structure for the BATHMAX 1500 design is the product of a two-phased development process. Initially, the structural configuration featured sloped and canted longitudinal bulkheads to maximize ship speed by minimizing lightship weight. An initial set of scantlings was generated by applying LR's rules. Later in the design cycle, a series of seakeeping tests was performed with a segmented ship model during which bending moments and shear forces were measured. The results were extrapolated to a probability level of 10^{-8} to predict long-term, maximum hull girder loads. At the same time, a full-ship FEM structural analysis model was built with the structural configuration revised to use vertical longitudinal bulkheads. The final scantlings were then determined by applying the predicted maximum hull girder loads to the FEM model.

The structural design for the R.J. PFEIFFER was an in-house effort by NASSCO. The resulting scantlings comply with the ABS rules in force at the delivery date plus any owner requirements for minimum thicknesses required by Matson Lines. The Pfeiffer is classed ABS ✠ A1 Container Carrier, ✠ AMS, ✠ ACCU.

Attachment 1 shows the BATHMAX 1500's structural configuration at the midship section. Considerable deadrise produces a stepped tank top arrangement. The midship section's structural arrangement for R.J. PFEIFFER is that of a very conventional container ship as indicated in Attachment 2.

5.5 Regulatory Analysis

It was perceived that, within the project's time and budget, a comprehensive analysis/comparison of various regulations from the international maritime governing body, International Maritime Organization (IMO), and the national regulations from the Coast Guard was feasible. This analysis proved to be very time consuming and tedious as the organization of the Code of Federal Regulations (CFR), which contain all pertinent U.S. regulations to shipping and ships is not a very user-friendly publication.

This process involved searching the CFR's and SOLAS for similar sections. A top-level reference index for life saving equipment and fire safety systems was done by matching up applicable CFR sections to their SOLAS counterpart. In this index, there are no direct comparisons, just a matching of the applicable sections, and all are matched to the corresponding SWBS number. The other analysis consisted of technically assessing

both texts and making a comment on any significant differences, similarities, or other noteworthy findings. This part is also SWBS categorized where feasible.

6.0 DISCUSSION of RESULTS

6.1 Database Deliverable

For the project's qualitative analysis portion, a tabular format was used to present the results. One file consisting of Microsoft Excel worksheets comprises the qualitative analysis of classification society rules. Each SWBS group, from 100 through 600 has its own worksheet, and is available by selecting the appropriate tab at the bottom of the Excel screen. A database example is shown in Figure 6.1.

SWBS	SWBS Description	ABS (baseline)	DNV	LR	CLASS NK	Significant Differences
506	Sounding Tubes					
507	Auxiliary and piping designation and markings					

Figure 6.1: Example format of tables for qualitative analysis

The "SWBS" column is simply the numbering system for the Navy's Standard Work Breakdown System, which is numbered in main groups from Group 0 through Group 9. In this analysis, only Groups 1-6 are included in the study. Under each main group is a series of numbers that relate to a sub topic.

The "Description" column is the designated topic for the corresponding SWBS number. This topic can be a system, a part, or components. The level of detail provided for a specific topic may not necessarily be entailed in solely one SWBS number, or the desired SWBS number may be too general for a specific item within that SWBS topic. To remedy this situation, many rows in the report have multiple entries for the same SWBS number.

The following four columns are the classification societies included in the study. In the qualitative analysis' case, ABS, Det Norske Veritas, Lloyd's Register, and Class NK are included. Within these cells is a reference to the section within the rules that describes the SWBS element, a listing of the topics covered in that section, and any other applicable comments of pertinent information.

The last column contains significant differences and/or similarities between the rules for each society. It can also describe relationships between society rules and maritime regulations and how the societies incorporate or otherwise treat sources such as IMO.

To use, simply go to the corresponding SWBS number for the topic of interest and read the entries in the table.

A quantitative analysis sample table, is shown in Figure 6.2,

Member	Item	As-Built or As-Designed	ABS	DNV	GL
Shell Plates	Keel	17.5 mm	21.1 mm	18.6 mm	17.0 mm
	"A" strake	17.5	21.1	17.2	17.0
Shell Longitudinals	L7-L9	320 x 12.0 HP #	340 x 14.0 HP #	280 x 12.0 HP #	300 x 12.0 HP #
	L11-L13	320 x 12.0 HP	400 x 14.0 HP	280 x 12.0 HP	320 x 12.0 HP

Figure 6.2: Example and excerpt of table for quantitative analysis

The first column entitled "Member" is the structural component's name and the location if necessary. Following the Member column is the "Item" column. The Item column contains the member's applicable structural pieces. The next column is the pre-determined "As-Built" or "As-Designed" designation. For the Pfeiffer, this column is "As-Built" and the listed scantling is the actual scantling on the vessel. The BATHMAX 1500 column is designated "As-Designed," since these are designed scantlings. The remaining columns are the calculated scantlings for the applicable piece from the listed class societies.

6.2 Discussion of Qualitative Analysis

This analysis is meant solely for a top-level type analysis, and not necessarily to do detailed design. The classification society focus is still mainly on structural integrity and safety, with the rest of the ship systems and safety features left largely to regulatory bodies. This being the case, there are many sections and topics where there are minimal, insignificant differences between societies, if any at all. With SOLAS and IMO regulating much of the safety aspects, all societies try to mold their rules to meet these regulations, or simply put the IMO text verbatim in the rules. Also, as mentioned before, the IACS Unified Requirements sets the basis for scantling calculations, which drives the societies toward more unity and less differences, significant ones at least. There are many smaller topics where a society may dedicate rules to, where another may not, but good engineering practice and experience will dictate what is done no matter what the classification society prints or does not print. All of the spreadsheets are in Appendix 2 at the end of the report.

6.2.1 SWBS 100 – Hull Structure

Classification society's number one impact-related topic is hull structure and the scantlings. Due to the IACS factor in society scantling determination, many end results of major scantlings are close to being the same. However, the route a society takes to achieve the end result can vary dramatically. ABS equations, in most cases, involve the least number of variables, and are the most simple. DNV, on the other hand, usually have the most intensive equations for scantlings. Organizational, DNV was very well organized and compact, having minimal references to other sections and chapters.

6.2.2 SWBS 200 – Propulsion Plant

For large ticket items such as marine engines, auxiliary engines, boilers, and other 'purchased' equipment, designers are minimally impacted by classification society rules. A designer is mainly concerned with proper selection of type-approved equipment from

vendors that will meet the performance specification. The societies do play a major role in the type-approval process for this equipment, but this is rarely dissected to the ship designer level. This category was difficult due to lack of detailed description with the SWBS system for the equipment and ship systems. A typical SWBS entry will consist of "Propulsion Gas Turbines." This is quite broad. Classification societies have many, many topics and sections under Gas Turbines that can be compared. Hence, one will find many sub-entries under a major SWBS topic such as described above. On the whole, there are minimal significant differences between societies in this section.

6.2.3 SWBS 300 – Electric Plant

There is an increasing reliance and shift toward commercial standards for shipboard electrical components. Societies are shifting responsibility to organizations such as the International Electrotechnical Commission (IEC) and the Institute of Electrical and Electronics Engineers (IEEE). Both of these organizations have developed detailed and universally accepted standards for shipboard electronics and electrical equipment. Throughout the society texts are references to specific publications from these organizations. While all societies do have significant sections relating to electrical engineering, the content is very uniform from society to society. Many of the emergency electrical power requirements are regulated by SOLAS, and are hence the same. Again, one society(s) may have more on a specific topic than another, for example, ABS is very limited on the information given on the lighting distribution area, where other societies state specific limitations on the number of lighting points and voltages. There are also many vessel-type specific rules for electrical plants. Special considerations are given to chemical, gas, oil, and passenger ships. But again, these special rules are mainly safety related, and are subject to SOLAS regulations, not individual societies.

6.2.4 SWBS 400 – Command and Surveillance

This SWBS is heavily weighted toward military/Navy applications. The few SWBS numbers applicable to commercial construction are topics such as radios, data processing, data display, electromagnetic protection, exterior communications, surface radar, and interior communications. Again, many of these features are seen as safety features, and are also regulated in part by IMO and flag states. In a number of cases, the society has taken verbatim text from IMO regulations for their test. An example is the radio system and the emergency procedure for the radio system. DNV simply uses the applicable sections from the IMO GMDSS Handbook, whereas the other societies make reference to it, or summarize the GMDSS text. The coverage by societies with respect to SWBS topics is not straightforward. Some societies will talk to a specific SWBS topic, where another may not. SWBS 400-type topics are minimally impacted directly from the classification society, or from the selection of different societies from ABS.

6.2.5 SWBS 500 – Auxiliary Systems (need to review and comment still)

As with all the other groups, there are minor differences in some emphasis of specific topics. ClassNK is more stringent in regard to reservoir capacity for compressed air starting systems than the others, but less detailed in an area like hydraulic fluid systems then the others, where DNV and ABS are the most in-depth and specific. A major difference in this section is with respect to the Fire Extinguishing system (SWBS 555). Lloyd's does not include any fire extinguishing protection text for vessels above 500 gross tons. They simply refer to SOLAS for ALL the rules. All the other societies include text and rules in their books on this topic. Some differences exist in design of rudders

and anchors. For example, ABS only allows stockless anchors to be considered, whereas the other societies discuss stocked and stockless anchors. In rudder design, LR's calculations for rudder scantlings are much more involved than the other societies. While the end results will be close to each other, the other societies make the calculation much more basic and easy than LR. Also, there are again many topics where off-the-shelf equipment would be used and the applicable sections in the rulebooks may not pertain to ship designer's daily design activities. Also, there are many SWBS numbers in this group which are not influenced by the societies, but rather from the regulatory bodies. Group 500 also includes many special or Navy-specific operations such as submarine operations, landing craft, and aircraft operations, which are not applicable to commercial shipping.

6.2.6 SWBS 600 – Outfit and Furnishings

With the SWBS organized and categorized the way it is, classification societies do not cover many of the individual SWBS numbers in this group. Although items such as furniture, messing spaces, services spaces, and offices are not covered by classification, some reference to this type of data is available in some of the smaller international regulatory bodies like the International Labour Conference which sets regulations regarding crew accommodations and general living conditions, and also falls under the IMO umbrella. Topics covered by classification societies are similar in this section. Some societies will cover a topic, whereas one will not however. An example of this is SWBS 613 (Rigging and Canvas). DNV has a dedicated section entitles "Masts and Rigging," where ABS has no reference to either in it's main class rules. LR and NK have some references to cargo rigging and masts, but also many references to special books for lifting appliances and/or cargo handling equipment that includes rigging and cargo protection.

6.3 Discussion of Quantitative Analysis

Attachment 3 tabulates the minimum rule scantlings for BATHMAX 1500 plus the "as-designed" final scantlings, while Attachment 4 does the same for the R.J. PFEIFFER, except that the final scantlings are the "as-built" sizes. These scantlings were obtained by application of each society's rules for local strength requirements. Since global strength requirements were not considered in sizing these members; the resulting scantlings should be considered as a first attempt to satisfy the class requirements. Comparing the sizes of a component could give some insight into the demands of each of the society's prescriptive rules for that component if there were enough examples available to make a valid comparison. However, in the present instance, the sample size (two designs) is probably too small to be statistically significant. Also, Finite Element Analysis has guided scantling design in recent years. A particular scantling may be reduced to that below the rulebook formula result if the proper analysis deems it is not necessary.

One key observation that was made is that DNV has a dynamic component to the sea pressure load applied to bottom structure. The dynamic component increases as draft decreases. This causes a ship, like the BATHMAX 1500, with considerable deadrise to have unusually thick bottom plate scantlings.

The next step in scantling development is satisfaction of the class requirements for global strength; this part of the process was performed for both designs using GL's Poseidon ND program. To meet rule requirements for moment of inertia and section

moduli for the midship section, the ability to perform scantling size iteration is needed. Such a capability could not easily be built into the spreadsheets that were developed to size the minimum scantlings for the ABS and DNV rules; however, the GL program could be used to permit manual scantling iteration in an efficient manner.

The maximum value of still water vertical bending moment amidships due to a wide range of loading cases is known for both designs; this value could be used in lieu of the GL rule minimum value. Since the BATHMAX 1500 employs an unconventional hull form, a series of seakeeping model tests were performed to gather the data needed to predict a long-term maximum value of wave vertical bending moment amidships for the ship's intended route. This value was used for the BATHMAX 1500, while the GL rule value for the minimum vertical wave bending moment was used for the R.J. PFEIFFER. The entire procedure and its results are documented in Appendix 9.1.

Finally, Table 6.1 lists the steel weight per unit length of the midship section's longitudinally continuous material for both designs. The "Minimum Scantlings" configuration refers to the rule minimum scantlings for each of the societies. The "Longitudinal Strength" configuration means that the scantlings satisfy both the rule minimum and global longitudinal strength requirements. The "As Built" configuration for R.J. PFEIFFER refers to the actual ship, which meets all ABS requirements in force at the delivery date (1992). As can be seen, there are no trends that can be confidently stated. ABS is the lightest for the BATHMAX, but not for the Pfeiffer. Perhaps, a better picture can be drawn from the Pfeiffer, a more conventional vessel. In the Pfeiffer, the societies are similar for weight per meter. For an approximately 200-meter vessel, this equates to over 400 metric tons between DNV and GL.

Weight of Longitudinal Material

Ship	Configuration	ABS	DNV	GL
BATHMAX 1500	Minimum Scantlings	18.31 t/m	20.52 t/m	21.21 t/m
	Longitudinal Strength	n/a	n/a	37.04 t
R.J. PFEIFFER	Minimum Scantlings	25.84 t/m	26.34 t/m	24.82 t/m
	Longitudinal Strength	n/a	n/a	26.21 t
	As-Built	29.41 t	n/a	n/a

Table 6.1: Steel Weight Per Unit of Midship Section Longitudinally

6.4 Discussion of Regulatory Analysis

Much progress has been made in the past to consolidate the international and domestic regulations as possible. The United States and Coast Guard have areas not covered by IMO regulations, areas where they strongly feel additional regulation or guidance is necessary. IMO also has some regulations not addressed in the CFR's. The CFR's also reference IMO regulations when applicable.

One topic of interest is the vast number of regulations dependant upon the specific type and trade of the vessel. As is the same with the classification societies, there are main class regulations, applicable to all vessels, along with large amounts of supplement regulations pertaining to specialized vessels.

The CFR's are organized into four main parts. The first, and largest part, are the Coast Guard and Department of Transportation regulations pertaining to shipping. The second are regulations from MARAD which address ports, financing, national emergencies, and the like. Parts 400-499 are applicable to Great Lakes Pilotage from the USCG. The final section is from the Federal Maritime Commission, which is involved in addressing foreign maritime matters and foreign commerce. The focus of this study stayed in the USCG section, which includes topics of interest such as load lines, marine engineering, different vessel types, electrical engineering, manning, equipment, materials, subdivision, stability, lifesaving arrangements, etc.

As displayed in the safety related index (Appendix 9.1.11), the CFR's have many more sections relating to a topic than does SOLAS. One thing this displays is an organizational difference in the layout of the texts. It also shows the repetition within the CFR's. The CFR's may have a paragraph on line-throwing appliances in four different parts. This spans from lifesaving appliances, materials and construction, to individual vessel type requirements. SOLAS is much more compact and condense, although more vague in many aspects than the CFR's. This impact is a matter of opinion to the user. It may provide problems in that more ambiguity leads to less direction in design, or too much regulation and information can lead to an overload and design restriction. Overall, SOLAS condenses topics into single sections, where the CFR's spread out the information about a topic into many sections, but provides much more detail.

Many calculations for specific items, such as bilge main diameters, are essentially the same, although the CFR's are based in the English system, where as SOLAS is metric. This causes minor differences in the final answer, but nothing significant. CFR's are more stringent in some areas such as markings and placards, more in-depth communications, and noise protection. There are also sections where one organization addressed the topic and the other did not, although it may be hidden within another section and not recognized. Where it was deemed applicable, a SWBS number was matched up to the topic. Since many of these topics are directly unrelated to SWBS numbers, many are blank. SWBS categories do not breakdown to the level of detail desired for such safety-related ship design topics.

7.0 FINDINGS

As with any research activity, it is worthwhile to recall steps and try to learn from these problems for future activities and as insight to the eventual outcomes in the project.

7.1 Statement of Work

As with many research and development projects, a concise definition is not always readily available, and many changes and lessons learned along the process can change such definitions of work and objectives. Included in the original scope of work was to define the problem and tasks. The panel was receptive to BIW's suggestions for definition of work and vision. Eventually, a final scope of work was defined and BIW proceeded with the project.

7.2 Tools and Training

Even when available, effective and efficient application of Computer Aided Engineering (CAE) tools can be difficult without proper training. Industry must take the initiative to actively engage in product evaluation and research to find products that meet their

needs. A dedicated effort must also be made to properly train and maintain a core-competency in that program in-house to maintain productive use and output from the tool.

For these reasons, programs that require considerable user interaction to solve complex, multi-faceted problems such as those authored by the classification societies for ship structural design, demand that the practitioner receive a sufficient amount of hands-on training by an experienced user.

7.3 Available Designs

Two container ship designs were selected for the quantitative analysis portion of this project. Perhaps some variation in ship type would have been preferable, but no other examples were available to BIW for use in this project. Concerns for "proprietary information" removed several other commercial designs from consideration. This is also impacted by limited newbuildings in the past decade within the U.S.

7.4 Work Breakdown Structures

An early decision in the Ship Designers' Handbook's development was the organizational structure of the classification society rule entries. The means by which the rule data is accessed, the index, is critical to the usability of the Handbook so it was important to the project team that the breakdown structure be familiar to American ship designers. The original RFP and proposals suggested that the US Navy Shipwork Breakdown Structure (SWBS) or the US Maritime Administration structure be used. Because of its wide acceptance in this country due to current emphasis on Navy projects, the SWBS was chosen.

One of the project's key findings is that the US Navy SWBS, while widely familiar among American shipyards, is not well suited to commercial design work or to modern production processes. The SWBS is an effective organizational tool for data such as specifications or weight for shipboard components and systems at a functional level only. For example, SWBS 521 contains the data associated with firemain systems, and SWBS 121, transverse bulkheads. Current shipbuilding products are oriented toward geographic sections of the ship like design zones, blocks, and units, rather than shipwide systems or discrete components.

Bath Iron Works has significant experience with the development and application of work breakdown structures (WBS) for ship design and building projects. From the Commercial Shipbuilding Focused Development Project of 1993 – 1996 BIW designers and engineers learned that world class commercial shipbuilders use a WBS that is more customer and production-friendly than the Navy SWBS. Exposure to the processes of Kvaerner Masa Yards in Finland and Mitsui Engineering and Shipbuilding in Japan revealed that the WBS at each of these yards reflects both the priorities of the customer in terms of concern for the cargo, and the emphasis on efficient construction. Discussion at the 23 August 2000 NSRP project review on the issue of SWBS included a suggestion that the Norwegian SFI (Skipsteknisk Forsknings Institutt) Group System be used.

In all of the WBS systems referenced, a group is defined to comprise all the ship systems that support the cargo or payload. Furthermore, recognizing that the cargo is of utmost importance to the shipowner, that group of the WBS is presented near the beginning, so the owner can readily locate data relative to the cargo.

The ship subsystem groups, what in Navy parlance have come to be known as H,M, and E systems, follow the cargo or payload system group. While not usually evident at the top level, these groups are subdivided by the ships' geographic area more than by system, i.e., forebody structure, machinery space piping, etc. Responsibility for building can then be appropriately assigned in the yard to production personnel. In addition, design and construction costs can be collected on a product basis.

An example of a typical world class commercial WBS is included below in Table 7.1 in order to illustrate this concept.

WBS	Title
1.0	Ship Architecture
2.0	Cargo Systems
3.0	Hull Structure
4.0	Outfit
5.0	Machinery
6.0	Electrical
7.0	Preservation

Table 7.1: World Class Commercial WBS Example

7.5 Recommendations for Further Work

As with any project, debate and discussion on topics and activities that should be investigated are initiated. This project is no different, as both the panel and BIW, recognized areas where follow-on work or new initiatives can be taken to task in the future as a result of this project.

It is recognized that there are international commercial WBS that are marine specific and are slanted for commercial ships and construction. The mentioned BIW experience with world class commercial WBS fueled ideas that are possible avenues for future development in the WBS area for the U.S. It would be a worthwhile venture to either fund a exploration or trade-off study on current work breakdown structures in the international market, or to develop a new U.S. standard commercial breakdown structure.

Another topic raised was the difficulty in using the CFR's. The CFR's are a maze of books, headings, and sub-headings. CFR compliance being a major aspect of U.S. ship design, construction, and operation, it would be useful to have a more concise and user-friendly interface, ideally electronic and portable. The Government Printing Office (GPO) does have online CFR search capabilities (http://www.access.gpo.gov/nara/cfr/cfr-table-search.html), which is a useful tool. However, for many designers, and operators, a fast, reliable Internet connection may not be possible. Having a CD-ROM collection and or interactive program to perform searches, accessing, and printing of the regulations that could be used on any PC whether it is shipboard or in engineering offices would provide much value to the industry. The GPO does offer "electronic" versions of the CFR's, but the price was very high ($115.00 for a single part of a title, or $23,000 for a one-year subscription) and the format was ASCII on 3.5 floppy disks, not CD-ROMs.

The conclusions and comparisons with respect to the quantitative structural analysis can be greatly expanded and become significant with the inclusion of many more vessels.

This should include a spectrum of vessel types and general sizes. Including more "standard" ships to a similar study will clearly identify confident trends and differences in structural theory between societies, and this can be expanded to trends for different ship types and between ship types and the like.

7.6 Software Evaluations

7.6.1 Germanischer Lloyd Poseidon ND 2.0

Germanischer Lloyd's Poseidon is Windows based and very graphical. It is a preliminary design tool that requires minimal knowledge of finite element techniques. There are two parts to Poseidon, one being a scantling calculation based on GL rules and first principles. This is then directly analyzed within the program from the built-in finite element techniques. Users must still complete a preliminary configuration of the structure, but scantlings are not necessary, the program will develop them. Quick turnaround between FE analysis and design changes is possible with this program.

7.6.2 ABS Rules on CD-ROM

ABS publishes a CD-ROM that includes their "Rules for Building and Classing Steel Vessels." This CD-ROM contains all parts in the SVR2000. The format is Adobe Acrobat Reader interface. Advanced, filtered search options are extremely limited with this approach, but keyword searches can be performed within the Acrobat Reader program. Selected pages can be printed, but text cannot be cut from the Acrobat Reader and pasted to other Applications. The files are linked and interactive. Clicking on references and sections from main pages will automatically take one to the clicked destination. This CD-ROM is included if a full set of hardcopy rules are purchased. It is also available individually for purchase.

7.6.3 IMO-Vega Database 6.0

This joint IMO-DNV developed database includes up to date IMO regulations and relevant national requirements from a number of flag states. The IMO-Vega database also includes historical data that is helpful for operators of older ships that may not fall under the latest regulations. Certain IMO publications/regulations are not included in the Vega database. Regulations not included, but available from IMO in electronic programs are the International Maritime Dangerous Goods (IMDG) Code, IMO Resolutions, and the GMDSS Handbook. Most all other IMO-based regulations are included in Vega. The interface is useful and easy to use. The user can initially input ship characteristics, which will filter in only the applicable regulations. This program is available for single computers or network systems. An update procedure is also available for purchase.

7.6.4 Lloyd's Register Rulefinder 8.0

Lloyd's Rulefinder software is an interactive program that allows the user to input the vessel's known characteristics up front which will automatically filter out unnecessary rules and regulations. The program is Windows based and is user-friendly. It also allows the user to designate what "type" of user they are, for example, a designer, operator, or surveyor, can be designated and the program will tailor output to suit the needs of that person. Rulefinder includes the Lloyd's Register Rules' latest edition for Classification of Steel Ships, along with relevant statutory regulations (IMO). Although ALL IMO regulations are not included, a large number are. Browsing is easily done with

word search, book search, and the like. Your characteristics for a particular vessel can be saved and recalled for later sessions.

7.6.5 ClassNK Technical Rules & Guidances on CD-ROM

Nippon Kaiji Kyokai makes a CD-ROM of their Technical Rules and Guidance available for purchase. The format is much like that of ABS's Adobe Reader configuration. However, NK uses a browser called DynaText for their configuration. The DynaText program is included on the CD-ROM and can be installed on your machine. The format is quite useful as cutting-pasting, searching, linking, bookmarking, and annotating features are present in the DynaText system. This allows one to add their own editorial notes on a specific item from the rules, or make links for easy bookmarks.

8.0 CONCLUSIONS and RECOMMENDATIONS

When taking all the topics covered by the base class society rules as a whole, the major significant differences are quite minimal. Even in dividing the rules into two major parts (structure and systems/machinery) the differences are not significant enough to warrant major design changes. With the IACS Unified Requirements' emergence and continuing evolution of dependence of FEM-type structural analysis, and IMO regulations, the underlying basis for almost all class society rules are the same. For structural items, IACS sets the minimum longitudinal strength standards. This is the building block for the remainder of the ship's structure. With this being the same minimum for all societies, the entire structure will fall into place and be similar on the whole. IACS also developed universal requirements for topics such as use of specific steels for specific hull members, loading information, steel casings, machinery space fire protection, and shafting requirements. Again, with these across the board requirements, it is difficult for class societies to deviate much from the prescribed requirement. A society may put in minor additions to complement the IACS requirement based on their assessment and history regarding these topics, but the basis remains the same. Larger than IACS in a matter of speaking are the IMO requirements, which strongly drive a large portion of the systems and safety aspects of a vessel. Many emergency systems, electrical systems, fire-fighting systems are directly taken from IMO texts such as SOLAS. For specialized vessels such as Oil Tankers, the class society rules will simply reference the IMO texts. Many class societies state up front that their written rules will meet all applicable IMO regulations, which again, causes the base of many topics to be the same, and not governed by the individual society.

For shipbuilders and design firms to make investments in the latest design tools from the U.S. and abroad is a major step toward increasing U.S. capability and productivity in the design and construction process. Simply buying these tools is not enough. Money must be spent training individuals and maintaining that capability in-house. The selection of such tools must be performed on a case-by-case basis by the individual yard or firm. Different software packages offer many of the same capabilities along with many specialized capabilities. Software programs such as the IMO Vega database can be an important tool for any yard or firm committed to commercial design and construction. This is not class society specific, but includes the vast array of IMO regulations regarding all vessels in all waters. It is a much more efficient process over thumbing through the numerous books that incorporate the IMO regulation umbrella. Class societies like Lloyd's Register and their Rulefinder software take the IMO Vega even farther in the fact that it incorporates their class rules with IMO regulations. However, the Rulefinder IMO portion is not as in-depth as the IMO Vega program however. All

societies offer an electronic version of their base rules that include search features that can facilitate quicker traversing through the rules.

Bath Iron Works has gained valuable experience in the realm of classification, classification requirements, and regulatory bodies and how they all interact together to get a vessel to sea. With the current shift in Navy and military toward commercial standards and standardization, societies like ABS will become important participants in the design and construction of Navy vessels from auxiliaries to combatant vessels in the future. DNV has published their rules for Naval Surface Craft, and ABS has such a publication in the works right now. The trend toward using class societies in naval construction makes it imperative that shipyards, regardless of their business base, become familiar with classification society rules. Also, groups within Bath Iron Works, and other companies within the General Dynamics Marine family are actively involved in commercial, classed designs. With the future vision of an increase in U.S. designed, built, and manned vessels, this knowledge base will be more important toward strengthening the U.S. shipbuilding industry as a whole.

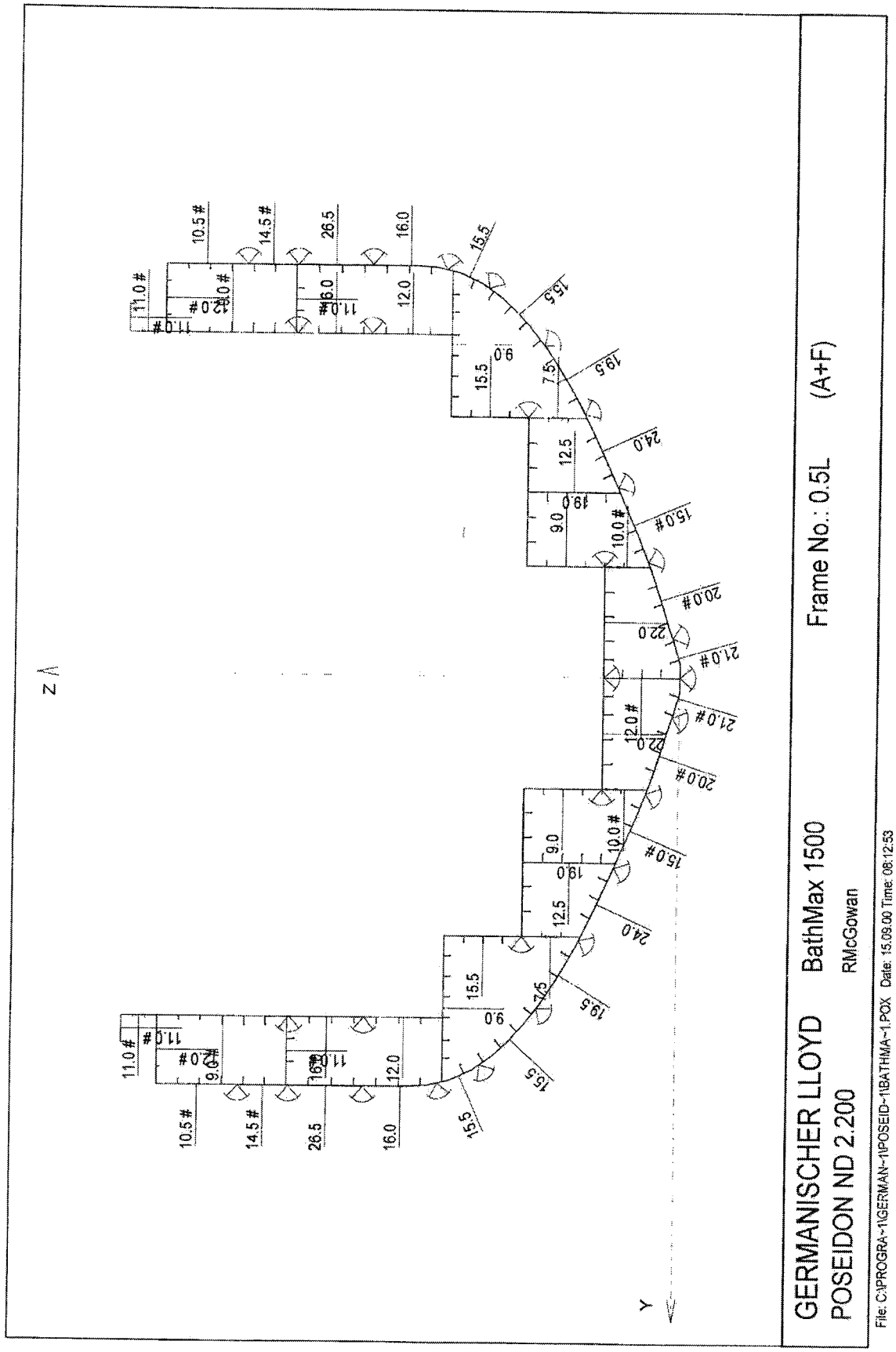
With the trend in classification societies becoming subject matter "experts" with respect to a certain type of vessel, it may be possible to have a customer approach a U.S. yard with a concept for a vessel that they require a class society other than ABS. All major classification societies have U.S. offices stationed in strategic locations, so its feasible to obtain the advice of foreign societies early in a design to be classed to that society. Having a point of initial reference to foreign societies is a first step that must be taken to ensure time and money savings later in the design process. These savings can be present in avoiding either paying outside contractors or significant internal ramp-up time when neither may be necessary if the class rules between societies are basically the same. Also this report provides designers, students, and managers, who are unfamiliar with the classification and regulation "choices" to gain an understanding of the process and the way they are heading in the future.

9.0 REFERENCES and SOURCES

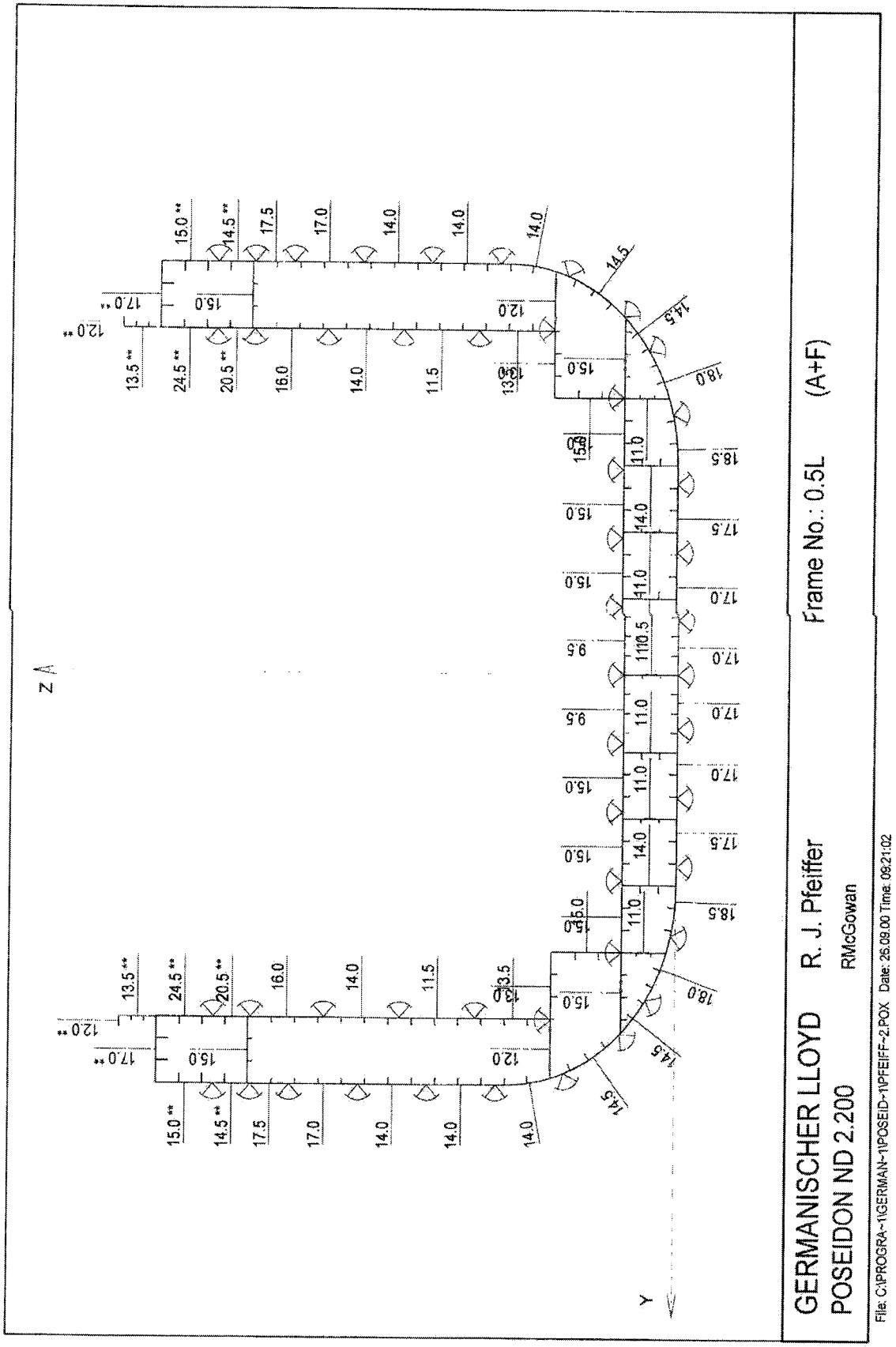
9.1 Report Attachments

1. BATHMAX 1500 – Midship Section – Structural Arrangement
2. R.J. PFEIFFER – Midship Section – Structural Arrangement
3. BATHMAX 1500 Scantlings
4. R.J. PFEIFFER Scantlings

9.1.1 BATHMAX 1500 – Midship Section – Structural Arrangement



9.1.2 R.J. PFEIFFER – Midship Section – Structural Arrangement



9.1.3 BATHMAX 1500 Scantlings

BATHMAX 1500 Scantlings

Member	Item	As-Designed	ABS	DNV	GL
Shell Plates	"A" strake	32.0 mm #	20.3 mm #	18.9 mm #	21.0 mm #
	"B" strake	32.0 #	20.3 #	12.6 #	20.0 #
	"C" strake	24.0 #	20.3 #	12.6 #	15.0 #
	"D" strake	22.0	20.3	12.6	24.0
	"E" strake	22.0	20.3	12.6	19.5
	"F" strake	20.0	20.3	12.6	15.5
	"G" strake	20.0	20.3	12.6	15.5
	"H" strake	22.0	16.1	15.0	16.0
	"I" strake	35.0	16.1	15.0	26.5
	"J" strake	45.0 #	13.7 #	19.1 #	14.5 #
	"K" strake	45.0 #	13.7 #	19.1 #	10.5 #
Shell Longitudinals	L1-L5	450x20.0x250x30.0 T #	265x33.0 WT #	200x26.5 WT #	300x12.0 HP #
	L7-L9	320x12.0 HP #	340x14.0 HP #	280x12.0 HP #	300x12.0 HP #
	L11-L13	320x12.0 HP	400x14.0 HP	280x12.0 HP	320x12.0 HP
	L15-L22	300x12.0 HP	320x12.0 HP	300x11.0 HP	320x12.0 HP
	L24-L29	300x12.0 HP	320x12.0 HP	370x15.0 HP	240x12.0 HP
	L31-L33	300x12.0 HP #	320x12.0 HP #	430x15.0 HP #	240x14.0 HP #
	L34-L35	400x35.0 FB #	400x30.0 FB #	400x30.0 FB #	180x9.0 HP #
Weather Deck	Plate	50.0 #	6.1 #	7.6 #	12.0 #
	Longitudinals	400x35.0 FB #	150x7.0 FB #	100x7.0 FB #	140x9.0 HP #
Second Deck (13.08 m ABL)	Plate	32.0 #	10.4 #	7.1 #	11.0 #
	Longitudinals	280x12.0 HP #	140x7.0 HP #	100x6.0 HP #	240x12.0 HP #
Tank Top (7.82 m ABL)	Plate	14.0	7.7	11.9	9.0
	Longitudinals	280x12.0 HP	160x7.0 HP	370x13.0 HP	220x11.0 HP
Tank Top (5.19 m ABL)	Plate	20.0	7.7	13.0	19.0
	Longitudinals	300x12.0 HP	340x14.0 HP	370x13.0 HP	280x12.0 HP
Tank Top (2.56 m ABL)	Plate	20.0	7.7	12.9	22.0
	Longitudinals	320x12.0 HP	180x16.5 WT	370x13.0 HP	320x12.0 HP
Longitudinal Bulkhead (CL)	Plate	24.0 #	16.0 #	11.7 #	12.0 #
	Longitudinals	320x12.0 HP #	230x26.0 WT #	300X12.0 HP #	280x12.0 HP #
Longitudinal Bulkhead (3.725 m off CL)	Plate 1	24.0 #	16.0 #	11.6 #	10.0 #
	Longitudinals 1	320x12.0 HP #	230x26.0 WT #	155x12.0 WT #	140x9.0 HP #
	Plate 2	16.0	8.2	14.0	9.0
	Longitudinals 2	320x12.0 HP	400x35.0 FB	400x35.0 FB	200x12.0 HP
Longitudinal Bulkhead (6.208 m off CL)	Plate	16.0	16.0	17.5	12.5
	Longitudinals	320x12.0 HP	205x23.0 WT	265x37.0 WT	300x12.0 HP

Longitudinal Bulkhead (8.691 m off CL)	Plate 1	16.0	7.6	14.0	7.5
	Longitudinals 1	300x12.0 HP	280x11.0 HP	180x9.0 HP	140x9.0 HP
	Plate 2	16.0	7.6	14.0	15.5
	Longitudinals 2	280x12.0 HP	280x11.0 HP	180x9.0 HP	220x11.0 HP
Longitudinal Bulkhead (11.450 m off CL)	Plate 1	14.0	8.2	19.0	12.0
	Longitudinals 1	280x12.0 HP	260x12.0 HP	200x9.0 HP	220x13.0 HP
	Plate 2	22.0	7.6	11.0	16.0
	Longitudinals 2	280x12.0 HP #	260x12.0 HP	300x14.0 HP	320x12.0 HP
	Plate 3	45.0 #	7.2 #	11.0 #	9.0 #
	Longitudinals 3	400x35.0 FB #	260x12.0 HP #	260x12.0 HP #	160x10.0 HP #
Hatch Coaming	Plate	45.0 #	11.0 #	11.0 #	11.0 #
	Longitudinals	400x35.0 FB #	100x10.0 FB #	150x10.0 FB #	80x5.0 HP #
Hatch Coaming Top	Plate	50.0 #	11.0 #	11.0 #	11.0 #
	Longitudinals	300x20 FB #	100x10.0 FB #	150x10.0 FB #	120x6.5 HP #
# denotes High Tensile Steel					

9.1.4 R.J. PFEIFFER Scantlings

R.J. PFEIFFER Scantlings

Member	Item	As-Built	ABS	DNV	GL
Shell Plates	Keel	17.5 mm	21.1 mm	18.6 mm	17.0 mm
	"A" strake	17.5	21.1	17.2	17.0
	"B" strake	17.5	21.1	17.2	17.5
	"C" strake	17.5	21.1	17.2	18.5
	"D" strake	17.5	21.1	17.2	18.0
	"E" strake	17.5	21.1	17.2	14.5
	"F" strake	17.5	21.1	17.2	14.5
	"G" strake	17.5	21.1	17.5	14.0
	"H" strake	17.5	21.1	17.5	14.0
	"I" strake	17.5	21.1	17.5	14.0
	"J" strake	17.5	21.1	17.5	17.0
	"K" strake	17.5	21.1	17.5	17.5
	"L" strake	28.6 #	14.6 #	22.4 #	14.5 #
	"M" strake	28.6 #	14.6 #	22.4 #	15.0 #
Shell Longitudinals	L1-L3	245x12.7x127x15.9 T #	265x33.0 WT #	230x30.0 WT #	260x10.0 HP #
	L5-L6	270x12.7x127x15.9 T #	265x37.0 WT #	230x30.0 WT #	280x11.0 HP #
	L8-L9	270x12.7x127x15.9 T #	265x37.0 WT #	230x30.0 WT #	280x11.0 HP #
	L11-L12	270x12.7x127x15.9 T #	265x37.0 WT #	230x30.0 WT #	280x11.0 HP #
	L14-L17	270x12.7x127x15.9 T #	265x37.0 WT #	230x30.0 WT #	260x10.0 HP #
	L19-L21	270x12.7x127x15.9 L #	265x37.0 WT #	203x102x19.0 L #	260x11.0 HP #
	L23-L29	203x152x15.9 L #	203x102x19.0 L #	203x152x25.4 L #	260x11.0 HP #
	L30-L31	178x102x12.7 L #	203x102x19.0 L #	203x152x25.4 L #	200x11.0 HP #
	L32-L34	178x102x9.5 L #	203x102x19.0 L #	203x152x25.4 L #	200x9.0 HP #
	L36-L38	304x25.4 FB #	400x30.0 FB #	400x30.0 FB #	380x22.0 FB #
Weather Deck	Plate	28.6 #	16.5 #	8.7 #	17.0 #
	Longitudinals	304x25.4 FB #	400x30.0 FB #	150x7.0 FB #	460x32.0 FB #
Second Deck (16.71 m ABL)	Plate	11.1	17.0	8.5	15.0
	Longitudinals	152x89x9.5 L #	203x102x25.4 L #	76x64x6.4 L #	180x10.0 HP #
Fourth Deck (4.83 m ABL)	Plate 1 (WT)	17.5	6.0	6.5	13.0
	Longitudinals 1	203x152x15.9 L #	203x152x25.4 L #	76x64x6.4 L #	260x11.0 HP #
	Plate 2 (NT)	11.1	6.0	6.5	12.0
Inner Bottom (2.08 m ABL)	Plate 1	15.9	6.0	16.9	9.5
	Longitudinals 1	245x12.7x127x15.9 T #	265x33.0 WT #	265x33.0 WT #	220x10.0 HP #
	Plate 2	15.9	6.0	15.9	15.0
	Longitudinals 2	245x12.7x127x15.9 T #	265x33.0 WT #	230x30.0 WT #	260x12.0 HP #
	Plate 3	15.9	6.0	15.9	15.0
	Longitudinals 3	245x12.7x127x15.9 T #	265x33.0 WT #	230x30.0 WT #	260x12.0 HP #
	Plate 4	17.5	6.0	15.9	15.0
	Longitudinals 4	270x12.7x127x15.9 T #	265x33.0 WT #	230x30.0 WT #	280x11.0 HP #
	Plate 5 (NT)	11.1	6.0	14.7	15.0
	Longitudinals 5	178x102x9.5 L #	265x33.0 WT #	203x102x19.0 L #	220x11.0 HP #

Longitudinal Bulkhead (13.51 m off CL)	Plate 1	15.9	10.3	15.7	13.5
	Longitudinals 1	203x152x15.9 L #	203x102x19.0 L #	203x102x19.0 L #	260x10.0 HP #
	Plate 2	15.9	10.3	15.7	11.5
	Longitudinals 2	203x152x15.9 L #	203x102x19.0 L #	203x102x19.0 L #	260x10.0 HP #
	Plate 3	14.3	10.3	15.7	14.0
	Longitudinals 3	178x102x12.7 L #	203x102x19.0 L #	203x102x19.0 L #	200x11.0 HP #
	Plate 4	11.1	10.3	15.7	16.0
	Longitudinals 4	178x102x9.5 L #	203x102x19.0 L #	203x102x19.0 L #	200x9.0 HP #
	Plate 5	28.6 #	10.3 #	15.7 #	20.5 #
	Longitudinals 5	305x25.4 FB #	203x102x19.0 L #	203x102x19.0 L #	300x17.0 FB #
	Plate 6	28.6 #	10.3 #	15.7 #	24.5 #
	Longitudinals 6	305x25.4 FB #	203x102x19.0 L #	203x102x19.0 L #	300x17.0 FB #
Longitudinal Bulkhead (10.90 m off CL)	Plate	17.5	11.3	18.8	15.0
	Longitudinals	270x12.7x127x15.9 L #	203x102x25.4 L #	203x102x25.4 L #	280x11.0 HP #
Longitudinal Girder (NT) (CL)	Plate	17.5	16.8	14.6	11.5
	Longitudinals	203x102x14.3 L #	203x102x25.4 L #	89x64x9.5 L #	140x6.0 HP #
Longitudinal Girder (WT) (3.05 m off CL)	Plate	14.3	16.8	14.6	11.0
	Longitudinals	203x152x11.1 L #	203x102x25.4 L #	89x64x9.5 L #	260x10.0 HP #
Longitudinal Girder (NT) (5.66 m off CL)	Plate	15.9	16.8	14.6	11.0
	Longitudinals	152x12.7 FB #	203x102x25.4 L #	89x64x9.5 L #	140x10.0 FB #
Longitudinal Girder (WT) (8.28 m off CL)	Plate	14.3	16.8	14.6	14.0
	Longitudinals	203x152x19.0 L #	203x102x25.4 L #	89x64x9.5 L #	280x11.0 HP #
Longitudinal Girder (NT) (10.90 m off CL)	Plate	11.1	11.3	14.6	11.0
	Longitudinals	152x12.7 FB #	203x102x25.4 L #	89x64x9.5 L #	130x10.0 FB #
Hatch Coaming	Plate	28.6 #	11.0 #	11.0 #	13.5 #
	Longitudinals	305x28.6 FB #	150x7.0 FB #	150x7.0 FB #	180x14.0 FB #
Hatch Coaming Top	Plate	28.6 #	11.0 #	11.0 #	12.0 #
# denotes High Tensile Steel					

9.2 Report References - Sources

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3. Hull Design POSEIDON User's Guide, Germanischer Lloyd AG, 2000
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5. NASSCO Company Website, http://www.nassco.com
6. Double Eagle Tankers – A Practical Application of the Alternate Compliance Program, R.M. Letourneat, Capt M. Rosecrans, and C. Dorchak, SNAME Marine Technology, Vol. 35, No. 4, October 1998, pp. 228-241
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10.0 APPENDIX 1

10.1.1 POSEIDON ND

Germanischer Lloyd furnished a copy of their POSEIDON ND software with a free user's license. POSEIDON was developed as a structural synthesis and analysis tool intended to facilitate the determination of ship scantlings during both design and construction phases. The designation POSEIDON ND indicates a revised and updated second-generation version of the original with a Windows 95/98 type of graphical user interface.

The program is well documented with a user's guide and a separate tutorial that guides a prospective user through the development of the midship section for a container ship. However, to become proficient in correctly applying the wide array of features offered by POSEIDON ND in an efficient manner, attendance at a formal training program would be highly desirable.

10.1.2 BATHMAX 1500

To develop the scantlings for the BATHMAX 1500 midship section using POSEIDON ND, it was necessary to:

1. Input the type of ship, principal dimensions, form coefficients, and maximum ship speed (Attachments 1-2)

2. Specify the material properties (Attachment 3)

3. Select a table of structural profiles (bulb flats, angles, flat bars, and tees are permitted) that contains the cross sectional area properties.

4. The selected table must exist prior to running the program; however, POSEIDON ND does come with several text files containing the necessary information for European and Japanese profiles. One of these tables can be used or modified as needed for use.

5. Generate a frame table in the ship's longitudinal direction (Attachment 4)

6. Generate a frame table in the ship's transverse and vertical directions (Attachment 5)

7. Provide a geometric and topologic description of the ship's transverse section with the aid of "functional" elements

   The geometry of a functional element is defined by a sequence of points and their connectors. Straight line and circular arc segments are used as connectors. Each functional element is named according to a convention; the use of such a scheme insures that the applicable sections of the GL Construction Rules will be automatically employed to size the stiffened plate structure being represented by the functional element.

8. For the BATHMAX 1500 design, midships does not coincide with an integral frame or station number, and no parallel midbody exists. Consequently, it was decided to model three transverse sections (frames 145, 163, and 181) and permit the program to interpolate for the midship section. Attachment 6 tabulates the functional elements

for frames 145, 163, and 181, while Attachment 7 illustrates the functional elements for the midship section.

9. Assign longitudinal plates and stiffeners to each functional element

   Specify the material and joint locations for each plate, but not the plating thickness. The program will assign a default thickness of 1.0 mm. Identify the material, location, and type of profile for each stiffener or group of stiffeners, but do not specify the stiffener dimensions. The program will assign a default profile, which will be the first entry in the structural profile table for that profile type. Attachments 8-9 list the plate and stiffener assignments, while Attachment 10 shows the default midship section.

10. After modeling the midship section, the user requests POSEIDON ND to generate a preliminary set of scantlings. These scantlings will satisfy the GL Construction Rules for local requirements and are produced by an iterative procedure starting with the default scantlings. The revised plate and stiffener assignments are compiled in Attachments 11-12, while Attachment 13 shows the preliminary midship section.

    When the preliminary scantlings are generated, the longitudinal strength in vertical bending is checked. The program calculates and compares the actual and required top and bottom flange hull girder section moduli plus the actual and required moments of inertia for the hull girder cross section. Values of the rule minimums for still water and wave bending moments are automatically computed, but the user can also enter actual bending moments, if known.

    Applying the GL values for the minimum still water and wave bending moments, the preliminary midship section's moment of inertia and section moduli were well below the GL requirements for longitudinal strength:

Moment of Inertia	154.409 m.4 (required)	66.725 m.4 (actual)
Section Modulus (deck)	15.381 m.3 (required)	5.762 m.3 (actual)
Section Modulus (bottom)	14.967 m.3 (required)	9.667 m.3 (actual)

11. For the BATHMAX 1500, the still water vertical bending moment amidships was computed for a range of loading cases, so that the actual maximum value was known. In addition, wave vertical bending moment amidships was measured during a series of seakeeping model tests in sea states of varying severity. The test results formed the basis for computing the maximum value of vertical bending moment on the ship's Seattle to Yokohama route with a probability level of 10^{-8}. These maximum values of still water and wave vertical bending moment were next input to the program by the user; the revised set of bending moments is tabulated in Attachments 14-15.

    For the preliminary scantlings, the midship section's moment of inertia and section moduli are again substantially below the GL requirements for longitudinal strength:

Moment of Inertia	173.344 m.4 (required)	66.725 m.4 (actual)
Section Modulus (deck)	17.267 m.3 (required)	5.762 m.3 (actual)
Section Modulus (bottom)	16.803 m.3 (required)	9.667 m.3 (actual)

    For the preliminary scantlings, the steel weight per unit length for the longitudinal material is 21.21 t./m.

12. To achieve adequate hull girder strength, the preliminary scantlings were increased in an iterative manner until both local and longitudinal strength requirements were satisfied. This process was performed manually, since POSEIDON ND does not possess such a capability.

13. Attachments 16-17 compile the final plate and stiffener scantlings, while Attachment 18 shows the final midship section. The actual and required hull girder beam properties for the final midship section are:

Moment of Inertia	173.344 m.4 (required)	170.952 m.4 (actual)
Section Modulus (deck)	15.829 m.3 (required)	17.990 m.3 (actual)
Section Modulus (bottom)	18.477 m.3 (required)	18.992 m.3 (actual)

For the final scantlings, the steel weight per unit length for the longitudinal material is 37.04 t./m.

10.1.3 R.J. PFEIFFER

POSEIDON ND was also used to determine the midship section scantlings for NASSCO's R.J. PFEIFFER. Familiarity with "how-to-use-the-program" that was gained by the BATHMAX 1500 application made this task much more tractable.

Tracing the midship section development process for R.J. PFEIFFER:

1. Ship particulars, steel properties, and frame space information were input and are presented on Attachments 19-23

2. A set of functional elements that describe the midship section's longitudinal material were created; the elements are listed on Attachment 24 and depicted in attachment 25

3. Plates and stiffeners were assigned to the functional elements; Attachments 26-27 tabulate the plate and stiffener assignments, and Attachment 28 shows the midship section prior to scantling generation

4. POSEIDON ND was asked to generate the preliminary scantlings, Attachments 29-30 list the resulting plate and stiffener dimensions; Attachment 31 shows the preliminary midship section

5. For the preliminary scantlings with the GL minimum values for still water and wave vertical bending moments, the midship section's moment of inertia and section moduli were equivalent to or greater than GL's requirements for longitudinal strength:

Moment of Inertia	100.549 m.4 (required)	163.590 m.4 (actual)
Section Modulus (deck)	11.972 m.3 (required)	11.825 m.3 (actual)
Section Modulus (bottom)	16.627 m.3 (required)	21.235 m.3 (actual)

For the preliminary scantlings, the steel weight per unit length for the longitudinal material is 24.82 t./m.

6. The actual maximum value of still water vertical bending moment exceeds the GL rule minimum value; Attachment 32 tabulates the applied vertical bending moment

7. For the preliminary scantlings with the increased still water vertical bending moment, the midship section's deck section modulus was somewhat below the GL requirements for longitudinal strength:

Moment of Inertia	118.141 m.4 (required)	163.590 m.4 (actual)
Section Modulus (deck)	14.066 m.3 (required)	11.825 m.3 (actual)
Section Modulus (bottom)	19.536 m.3 (required)	21.235 m.3 (actual)

8. A final set scantlings was obtained by increasing plating thickness in way of the box girders and hatch coamings. The resulting plate and stiffener sizes are listed in Attachments 33-34, while Attachment 35 illustrates the revised midship section

9. For the final scantlings, the midship section's moment of inertia and section moduli meet or exceed GL's requirements for longitudinal strength:

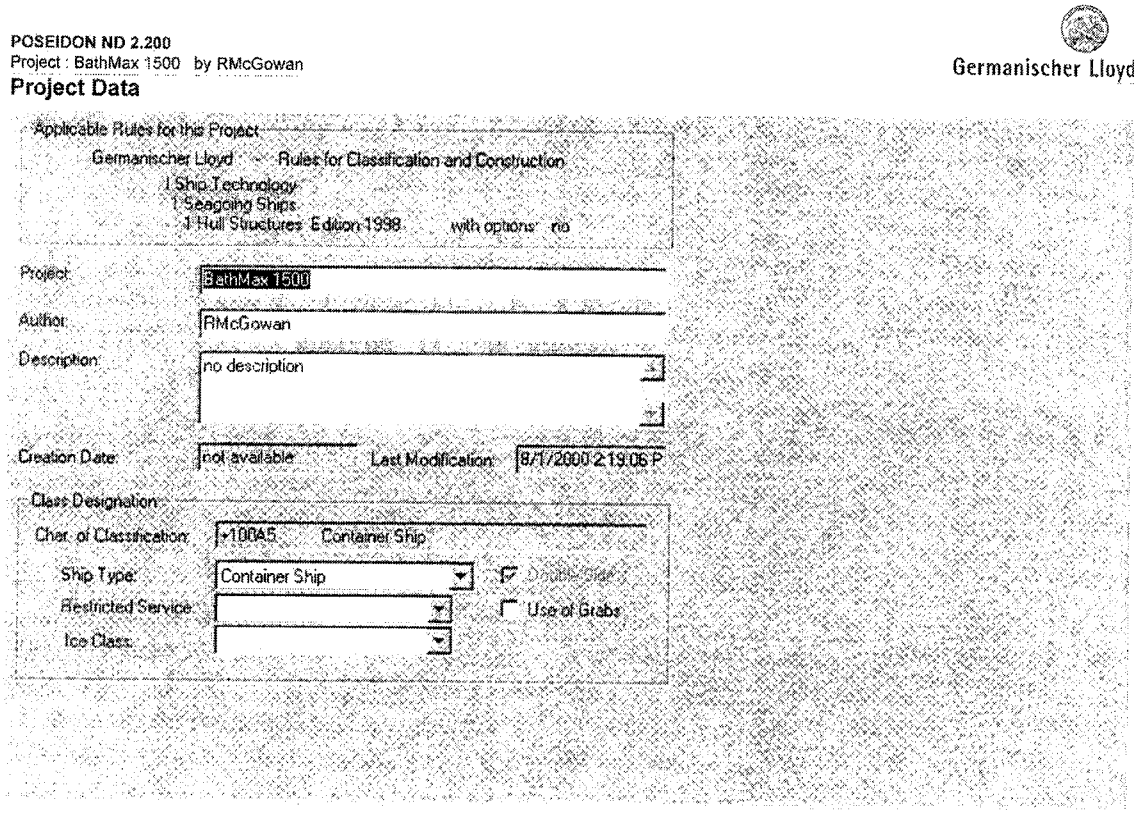
Moment of Inertia	118.141 m.4 (required)	186.792 m.4 (actual)
Section Modulus (deck)	14.066 m.3 (required)	14.118 m.3 (actual)
Section Modulus (bottom)	19.536 m.3 (required)	22.428 m.3 (actual)

The final steel weight per unit length for the longitudinal material is 26.21 t./m.

Attachments for Appendix 10.1

1. BATHMAX 1500 – Project Data
2. BATHMAX 1500 – Principal Dimensions
3. BATHMAX 1500 – Materials
4. BATHMAX 1500 – Frame Table in X-Direction
5. BATHMAX 1500 – Frame Table in Y- and Z-Direction
6. BATHMAX 1500 – Shape Representation – Frames 145, 163, and 181
7. BATHMAX 1500 – Functional Elements – Midship Section
8. BATHMAX 1500 – Plate Arrangement – Midship Section – Default Scantlings
9. BATHMAX 1500 – Stiffener Arrangement – Midship Section – Default Scantlings
10. BATHMAX 1500 – Midship Section – Default Scantlings
11. BATHMAX 1500 – Plate Arrangement – Midship Section – GL Minimum Scantlings
12. BATHMAX 1500 – Stiffener Arrangement – Midship Section – GL Minimum Scantlings
13. BATHMAX 1500 – Midship Section – GL Minimum Scantlings
14. BATHMAX 1500 – Still Water - Vertical Bending Moment and Shear Force
15. BATHMAX 1500 – Wave Bending Moments and Shear Forces
16. BATHMAX 1500 – Plate Arrangement – Midship Section – GL Final Scantlings
17. BATHMAX 1500 – Stiffener Arrangement – Midship Section – GL Final Scantlings
18. BATHMAX 1500 – Midship Section – GL Final Scantlings
19. R.J. PFEIFFER – Project Data
20. R.J. PFEIFFER – Principal Dimensions
21. R.J. PFEIFFER – Materials
22. R.J. PFEIFFER – Frame Table in X-Direction
23. R.J. PFEIFFER – Frame Table in Y- and Z-Direction
24. R.J. PFEIFFER – Shape Representation – Midship Section
25. R.J. PFEIFFER – Functional Elements – Midship Section
26. R.J. PFEIFFER – Plate Arrangement – Midship Section – Default Scantlings
27. R.J. PFEIFFER – Stiffener Arrangement – Midship Section – Default Scantlings
28. R.J. PFEIFFER – Midship Section – Default Scantlings
29. R.J. PFEIFFER – Plate Arrangement – Midship Section – GL Minimum Scantlings
30. R.J. PFEIFFER – Stiffener Arrangement – Midship Section – GL Minimum Scantlings
31. R.J. PFEIFFER – Midship Section – GL Minimum Scantlings
32. R.J. PFEIFFER – Still Water - Vertical Bending Moment and Shear Force
33. R.J. PFEIFFER – Plate Arrangement – Midship Section – GL Final Scantlings
34. R.J. PFEIFFER – Stiffener Arrangement – Midship Section – GL Final Scantlings
35. R.J. PFEIFFER – Midship Section – GL Final Scantlings

Attachment 1 – BATHMAX 1500 Project Data



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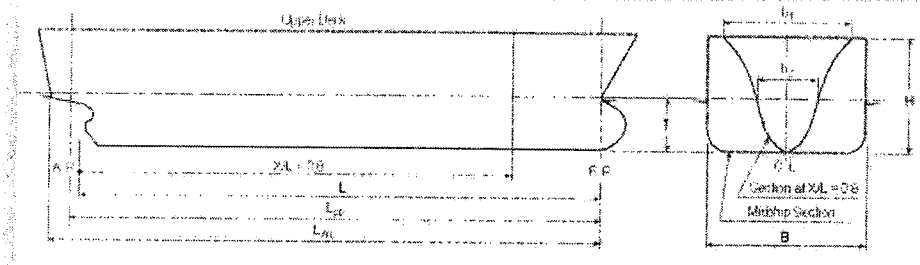
Attachment 2 – BATHMAX 1500 Principal Dimensions

POSEIDON ND 2.200
Project : BathMax 1500 by RMcGowan

Germanischer Lloyd

Principal Dimensions

Length betw. perpendiculars	Lpp	247.600	m	Block coefficient	CB	0.431
Length of water line at T	Lwl	248.370	m	Max. speed in calm water	Vo	33.200 kn
Scantling length	L	240.919	m	Min. draught at FP in ballast	Tb	9.000 m
Breath	B	27.500	m	Deadweight		12145.000 tdw
Depth	H	17.400	m	Breath of upper const. Deck at 0.8*L	b1	0.000 m
Scantling draught	T	9.000	m	Breath of waterline at 0.8*L	b2	0.000 m



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Attachment 3 – BATHMAX 1500 Materials

Material Number	E-Modulus [kN/m^2]	G-Modulus [kN/m^2]	Material Density [kg/mm^2]	Yield Stress [N/mm^2]	Remark
1	206000000	79230769	8000	235	
2	206000000	79230769	8000	315	
3	206000000	79230769	8000	355	
4	206000000	79230769	8000	390	

Attachment 4 – BATHMAX 1500 Frame Table in X-Direction

Frame No.	Frame Spacing [mm]	M. Line	X_p-Coordinate Fr.aft PP [m]	X/L
0	800	Forward	-7.200	0.0000
325	800	Forward	252.800	1.0000

Attachment 5 – BATHMAX 1500 Frame Table in Y- and Z-Direction

Name	No	Spacing [mm]	Y [mm]	Z [mm]	Frame No.	F/A	Sym
L_0	1	0.0	0.0		0.5L	A+F	P
L_1	1	621.0	621.0		0.5L	A+F	P+S
L_2	1	621.0	1242.0		0.5L	A+F	P+S
L_3	1	827.7	2069.7		0.5L	A+F	P+S
L_4	1	827.7	2897.3		0.5L	A+F	P+S
L_5	1	827.7	3725.0		0.5L	A+F	P+S
L_6	1	827.7	4552.7		0.5L	A+F	P+S
L_7	1	827.7	5380.3		0.5L	A+F	P+S
L_8	1	827.7	6208.0		0.5L	A+F	P+S
L_9	1	827.7	7035.7		0.5L	A+F	P+S
L_10	1	827.7	7863.3		0.5L	A+F	P+S
L_11	1	689.8	8691.0		0.5L	A+F	P+S
L_12	1	689.8	9380.8		0.5L	A+F	P+S
L_13	1	689.8	10070.5		0.5L	A+F	P+S
L_14	1	689.8	10760.3		0.5L	A+F	P+S
L_15	1	689.8	11450.0		0.5L	A+F	P+S
L_16	1	575.0	12025.0		0.5L	A+F	P+S
L_17	1	575.0	12600.0		0.5L	A+F	P+S
L_18	1	575.0	13175.0		0.5L	A+F	P+S
L_19	1	575.0	13750.0		0.5L	A+F	P+S
L_20	1	640.0		0.0	0.5L	A+F	P+S
L_21	1	640.0		640.0	0.5L	A+F	P+S
L_22	1	640.0		1280.0	0.5L	A+F	P+S
L_23	1	640.0		1920.0	0.5L	A+F	P+S
L_24	1	640.0		2560.0	0.5L	A+F	P+S
L_25	1	657.5		3217.5	0.5L	A+F	P+S
L_26	1	657.5		3875.0	0.5L	A+F	P+S
L_27	1	657.5		4532.5	0.5L	A+F	P+S
L_28	1	657.5		5190.0	0.5L	A+F	P+S
L_29	1	657.5		5847.5	0.5L	A+F	P+S
L_30	1	657.5		6505.0	0.5L	A+F	P+S
L_31	1	657.5		7162.5	0.5L	A+F	P+S
L_32	1	657.5		7820.0	0.5L	A+F	P+S
L_33	1	657.5		8477.5	0.5L	A+F	P+S
L_34	1	657.5		9135.0	0.5L	A+F	P+S
L_35	1	657.5		9792.5	0.5L	A+F	P+S
L_36	1	657.5		10450.0	0.5L	A+F	P+S
L_37	1	657.5		11107.5	0.5L	A+F	P+S
L_38	1	657.5		11765.0	0.5L	A+F	P+S
L_39	1	657.5		12422.5	0.5L	A+F	P+S
L_40	1	657.5		13080.0	0.5L	A+F	P+S
L_41	1	720.0		13800.0	0.5L	A+F	P+S
L_42	1	720.0		14520.0	0.5L	A+F	P+S
L_43	1	720.0		15240.0	0.5L	A+F	P+S
L_44	1	720.0		15960.0	0.5L	A+F	P+S
L_45	1	720.0		16680.0	0.5L	A+F	P+S
L_46	1	720.0		17400.0	0.5L	A+F	P+S
L_47	1	400.0		17800.0	0.5L	A+F	P+S
L_48	1	400.0		18200.0	0.5L	A+F	P+S
L_49	1	400.0		18600.0	0.5L	A+F	P+S

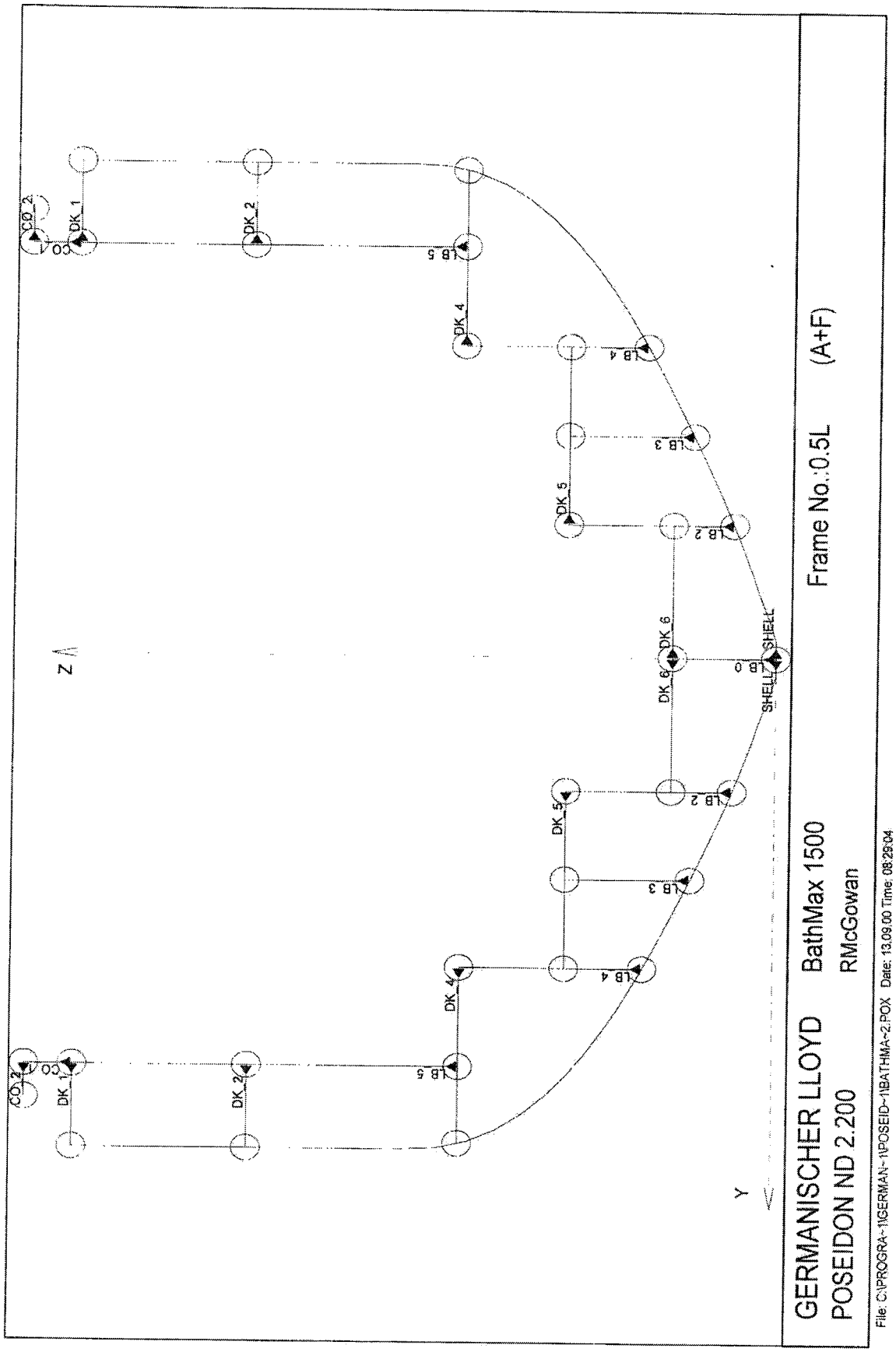
Attachment 6 – BATHMAX 1500 Shape Representation: Frames 145, 163, and 181

Functional Element	Description	Frame No.	F/A	Sym	No.	Y [mm]	Z [mm]	LT
CO_1	Hatch Coaming	145	F	P+S	1	L_15	L_46	3
					2	L_15	L_49	
CO_2	Hatch Coaming Flange	145	F	P+S	1	CO_1	L_49	3
					2	CO_1+929	L_49	
DK_1	Weather Deck	145	F	P+S	1	L_15	L_46	3
					2	SHELL	L_46	
DK_2	Tank Top - 13.08 m ABL	145	F	P+S	1	L_15	L_40	3
					2	SHELL	L_40	
DK_4	Tank Top - 7.82 m ABL	145	F	P+S	1	L_11	L_32	3
					2	SHELL	L_32	
DK_5	Tank Top - 5.19 m ABL	145	F	P+S	1	L_5	L_28	3
					2	L_11	L_28	
DK_6	Tank Top - 2.56 m ABL	145	F	P+S	1	L_0	L_24	3
					2	L_5	L_24	
LB_0	Long'l Bhd - CL	145	F	P	1	L_0	SHELL	3
					2	L_0	L_24	
LB_2	Long'l Bhd - 3.725 m off CL	145	F	P+S	1	L_5	SHELL	3
					2	L_5	L_28	
LB_3	Long'l Bhd - 6.208 m off CL	145	F	P+S	1	L_8	SHELL	3
					2	L_8	L_28	
LB_4	Long'l Bhd - 8.691 m off CL	145	F	P+S	1	L_11	SHELL	3
					2	L_11	L_32	
LB_5	Long'l Bhd - 11.450 m off CL	145	F	P+S	1	L_15	L_32	3
					2	L_15	L_46	
SHELL	Whole Shell	145	F	P+S	1	0.0	0.0	1
					2	500.0	0.0	1
					3	621.0	27.8	1
					4	1242.0	173.7	1
					5	1828.8	402.9	1
					6	2579.3	638.2	1
					7	3326.2	884.1	1
					8	4067.4	1147.0	1
					9	4801.0	1430.4	1
					10	5527.4	1731.8	1
					11	6248.7	2045.1	1
					12	6967.2	2364.8	1
					13	7681.9	2693.0	1
					14	8390.6	3033.9	1
					15	9090.6	3392.4	1
					16	9778.9	3772.7	1
					17	10451.8	4179.7	1
					18	11103.5	4619.7	1
					19	11726.0	5100.0	1
					20	12306.7	5629.9	1
					21	12827.6	6218.5	1
					22	13262.3	6872.9	1
					23	13576.5	7592.5	1
					24	13731.4	8361.9	1
					25	13748.4	9147.8	1
					26	13750.0	9934.2	1
					27	13750.0	17400.0	

Functional Element	Description	Frame No.	F/A	Sym	No.	Y [mm]	Z [mm]	LT
CO_1	Hatch Coaming	163	A+F	P+S	1	L_15	L_46	3
					2	L_15	L_49	
CO_2	Hatch Coaming Flange	163	A+F	P+S	1	CO_1	L_49	3
					2	CO_1+929	L_49	
DK_1	Weather Deck	163	A+F	P+S	1	L_15	L_46	3
					2	SHELL	L_46	
DK_2	Tank Top - 13.08 m ABL	163	A+F	P+S	1	L_15	L_40	3
					2	SHELL	L_40	
DK_4	Tank Top - 7.82 m ABL	163	A+F	P+S	1	L_11	L_32	3
					2	SHELL	L_32	
DK_5	Tank Top - 5.19 m ABL	163	A+F	P+S	1	L_5	L_28	3
					2	L_11	L_28	
DK_6	Tank Top - 2.56 m ABL	163	A+F	P+S	1	L_0	L_24	3
					2	L_5	L_24	
LB_0	Long'l Bhd - CL	163	A+F	P	1	L_0	SHELL	3
					2	L_0	L_24	
LB_2	Long'l Bhd - 3.725 m off CL	163	A+F	P+S	1	L_5	SHELL	3
					2	L_5	L_28	
LB_3	Long'l Bhd - 6.208 m off CL	163	A+F	P+S	1	L_8	SHELL	3
					2	L_8	L_28	
LB_4	Long'l Bhd - 8.691 m off CL	163	A+F	P+S	1	L_11	SHELL	3
					2	L_11	L_32	
LB_5	Long'l Bhd - 11.450 m off CL	163	A+F	P+S	1	L_15	L_32	3
					2	L_15	L_46	
SHELL	Whole Shell	163	A+F	P+S	1	0.0	0.0	1
					2	500.0	0.0	1
					3	621.0	28.2	1
					4	1242.0	176.3	1
					5	1833.4	406.5	1
					6	2583.0	642.9	1
					7	3329.2	890.1	1
					8	4069.4	1154.3	1
					9	4802.0	1439.0	1
					10	5527.5	1741.2	1
					11	6248.1	2055.1	1
					12	6966.1	2375.0	1
					13	7680.2	2703.3	1
					14	8388.4	3044.1	1
					15	9088.0	3402.4	1
					16	9776.1	3782.2	1
					17	10448.8	4188.5	1
					18	11100.6	4627.7	1
					19	11723.1	5107.2	1
					20	12304.1	5636.1	1
					21	12825.6	6223.6	1
					22	13261.2	6876.9	1
					23	13575.9	7595.8	1
					24	13731.2	8364.6	1
					25	13748.3	9150.0	1
					26	13750.0	9936.0	1
					27	13750.0	17400.0	

Functional Element	Description	Frame No.	F/A	Sym	No.	Y [mm]	Z [mm]	LT
CO_1	Hatch Coaming	181	A	P+S	1	L_15	L_46	3
					2	L_15	L_49	
CO_2	Hatch Coaming Flange	181	A	P+S	1	CO_1	L_49	3
					2	CO_1+929	L_49	
DK_1	Weather Deck	181	A	P+S	1	L_15	L_46	3
					2	SHELL	L_46	
DK_2	Tank Top - 13.08 m ABL	181	A	P+S	1	L_15	L_40	3
					2	SHELL	L_40	
DK_4	Tank Top - 7.82 m ABL	181	A	P+S	1	L_11	L_32	3
					2	SHELL	L_32	
DK_5	Tank Top - 5.19 m ABL	181	A	P+S	1	L_5	L_28	3
					2	L_11	L_28	
DK_6	Tank Top - 2.56 m ABL	181	A	P+S	1	L_0	L_24	3
					2	L_5	L_24	
LB_0	Long'l Bhd - CL	181	A	P	1	L_0	SHELL	3
					2	L_0	L_24	
LB_2	Long'l Bhd - 3.725 m off CL	181	A	P+S	1	L_5	SHELL	3
					2	L_5	L_28	
LB_3	Long'l Bhd - 6.208 m off CL	181	A	P+S	1	L_8	SHELL	3
					2	L_8	L_28	
LB_4	Long'l Bhd - 8.691 m off CL	181	A	P+S	1	L_11	SHELL	3
					2	L_11	L_32	
LB_5	Long'l Bhd - 11.450 m off CL	181	A	P+S	1	L_15	L_32	3
					2	L_15	L_46	
SHELL	Whole Shell	181	A	P+S	1	0.0	0.0	1
					2	500.0	0.0	1
					3	621.0	53.6	1
					4	1242.0	323.9	1
					5	2263.5	571.7	1
					6	3013.1	829.0	1
					7	3758.1	1101.9	1
					8	4495.4	1394.9	1
					9	5225.8	1704.7	1
					10	5951.9	2024.8	1
					11	6676.2	2348.7	1
					12	7397.7	2678.9	1
					13	8114.0	3020.0	1
					14	8822.2	3377.9	1
					15	9519.0	3757.3	1
					16	10200.2	4164.0	1
					17	10859.7	4605.0	1
					18	11489.3	5087.6	1
					19	12077.4	5619.8	1
					20	12608.6	6208.7	1
					21	13062.5	6858.7	1
					22	13415.1	7568.6	1
					23	13646.8	8326.4	1
					24	13744.4	9112.8	1
					25	13750.0	9906.2	1
					26	13750.0	17400.0	

Attachment 7 – BATHMAX 1500 Functional Elements: Midship Section



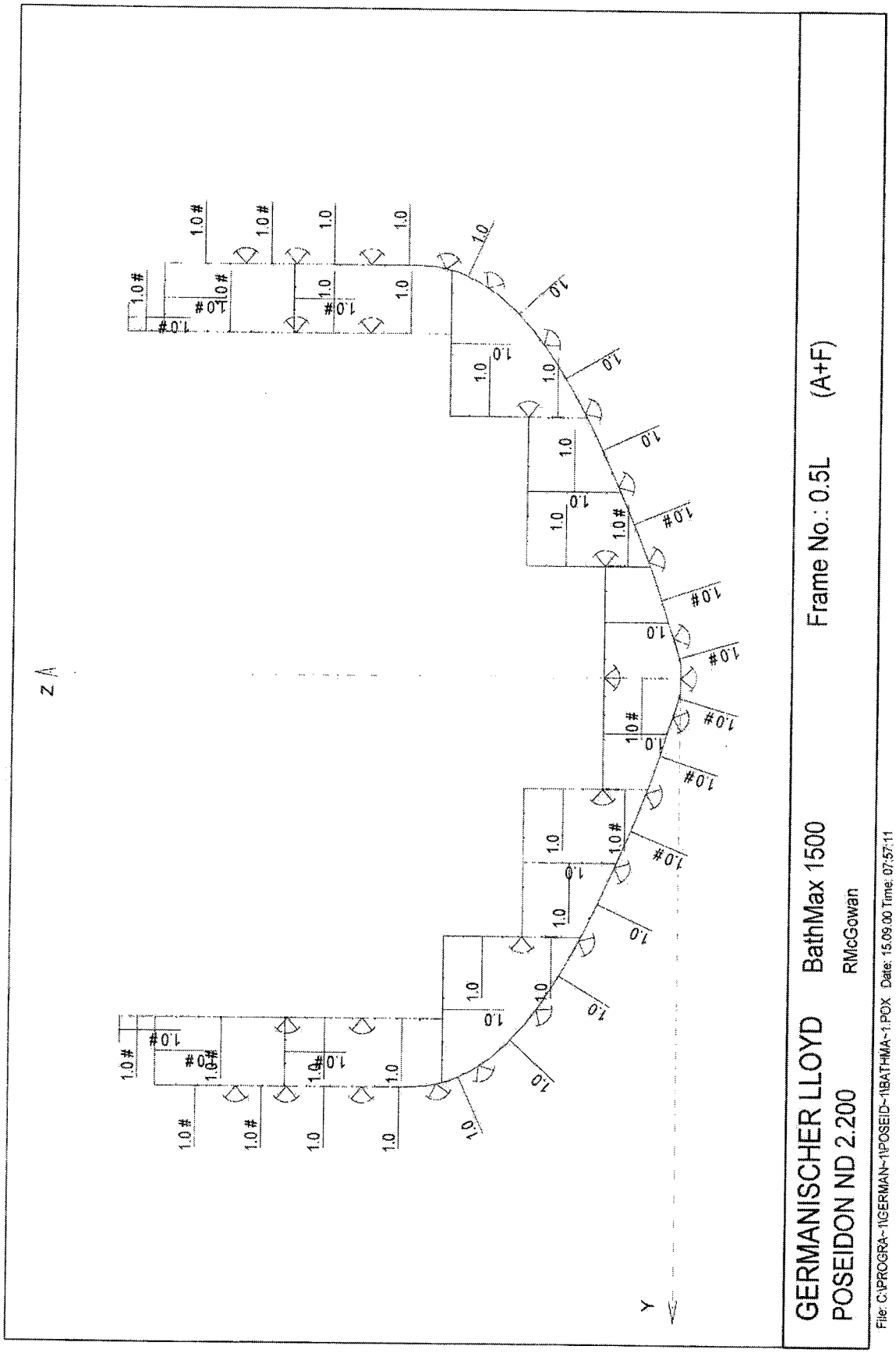
Attachment 8 – BATHMAX 1500 Plate Arrangement: Midship Section – Default Scantlings

Functional Element	Item	Start of Plate	M.Line	Sym.	Design Criteria
Attributes		End of Plate	t [mm]	Mat	
SHELL	A	BEGIN B=1350.0	Right	P+S 4	S
SHELL	B	AUTO B=2700.0	Right	P+S 4	S
SHELL	C	AUTO B=2700.0	Right	P+S 4	S
SHELL	D	AUTO B=2700.0	Right	P+S 1	S
SHELL	E	AUTO B=2700.0	Right	P+S 1	S
SHELL	F	AUTO B=2700.0	Right	P+S 1	S
SHELL	G	AUTO ;Z=8000.0	Right	P+S 1	S
SHELL	H	AUTO ;Z=10500.0	Right	P+S 1	S
SHELL	I	AUTO ;Z=13000.0	Right	P+S 1	S
SHELL	J	AUTO END-2700.0	Right	P+S 4	S
SHELL	K	AUTO END	Right	P+S 4	S
CO_1	pl.1	BEGIN END	Right	P+S 4	CO
CO_2	pl.1	BEGIN END	Right	P+S 4	CO
DK_1	pl.1	BEGIN END	Right	P+S 4	WD
DK_2	pl.1	BEGIN END	Right	P+S 4	WT
DK_4	pl.1	BEGIN END	Right	P+S 1	WT
DK_5	pl.1	BEGIN END	Right	P+S 1	WT
DK_6	pl.1	BEGIN END	Right	P+S 1	IB
LB_0	pl.1	BEGIN END	Right	P 4	WT
LB_2	pl.1	BEGIN L_24	Right	P+S 4	
LB_2	pl.2	AUTO END	Right	P+S 1	WT
LB_3	pl.1	BEGIN END	Right	P+S 1	WT
LB_4	pl.1	BEGIN L_28	Right	P+S 1	
LB_4	pl.2	AUTO END	Right	P+S 1	WT
LB_5	pl.1	BEGIN ;Z=10500.0	Right	P+S 1	WT
LB_5	pl.2	AUTO ;Z=13000.0	Right	P+S 1	WT
LB_5	pl.3	AUTO END	Right	P+S 4	WT

Attachment 9 – BATHMAX 1500 Stiffener Arrangement: Midship Section – Default Scantlings

Functional Element	Item	Start of Spacing	a [mm]	Type	Dimensions		
Attributes		End of Spacing	l [mm]	M.Line	Rot.	Mat.	Sym.
SHELL	1	L_1	0	HP	50*4.0		
		n=1	0	MF	R90.0	4	P+S
SHELL	2	L_2	n=5	HP	50*4.0		
		L_5	0	MF	R90.0	4	P+S
SHELL	3	L_5	n=5	HP	50*4.0		
		L_8	0	MF	R90.0	4	P+S
SHELL	4	L_8	n=5	HP	50*4.0		
		L_11	0	MF	R90.0	1	P+S
SHELL	5	L_11	n=10	HP	50*4.0		
		L_32	0	MF	R90.0	1	P+S
SHELL	6	L_32+751.4	751	HP	50*4.0		
		L_40-751.4	0	MF	R90.0	1	P+S
SHELL	7	L_41	n=3	HP	50*4.0		
		L_43	0	MF	R90.0	1	P+S
SHELL	8	L_44	n=2	HP	50*4.0		
		L_45	0	MF	R90.0	4	P+S
LB_0	1	L_21	n=3	HP	50*4.0		
		L_23	0	MF	R90.0	4	P
LB_2	1	L_23	0	HP	50*4.0		
		n=1	0	OF	R90.0	4	P+S
LB_2	2	L_24	0	HP	50*4.0		
		n=1	0	OF	R90.0	1	P+S
LB_2	3	L_25	n=3	HP	50*4.0		
		L_27	0	OF	R90.0	1	P+S
LB_3	1	L_24	n=4	HP	50*4.0		
		L_27	0	MF	R90.0	1	P+S
LB_4	1	L_26	n=2	HP	50*4.0		
		L_27	0	MF	R90.0	1	P+S
LB_4	2	L_29	n=3	HP	50*4.0		
		L_31	0	OF	R90.0	1	P+S
LB_5	1	L_32+751.4	751	HP	50*4.0		
		L_40-751.4	0	OF	R90.0	1	P+S
LB_5	2	L_41	n=3	HP	50*4.0		
		L_43	0	OF	R90.0	1	P+S
LB_5	3	L_44	n=2	HP	50*4.0		
		L_45	0	OF	R90.0	4	P+S
DK_1	1	L_16	n=3	HP	50*4.0		
		L_18	0	OF	R90.0	4	P+S
DK_2	1	L_15+766.7	n=2	HP	50*4.0		
		L_19-766.7	0	OF	R90.0	4	P+S
DK_4	3	L_15+766.7	n=2	HP	50*4.0		
		L_19-766.7	0	OF	R90.0	1	P+S
DK_4	1	L_12	n=3	HP	50*4.0		
		L_14	0	OF	R90.0	1	P+S
DK_4	2	L_15	0	HP	50*4.0		
		n=1	0	OF	R90.0	1	P+S
DK_5	1	L_6	n=2	HP	50*4.0		
		L_7	0	OF	R90.0	1	P+S
DK_5	2	L_9	n=2	HP	50*4.0		
		L_10	0	OF	R90.0	1	P+S
DK_6	1	L_1	0	HP	50*4.0		
		n=1	0	OF	R90.0	1	P+S
DK_6	2	L_2	n=3	HP	50*4.0		
		L_4	0	OF	R90.0	1	P+S
CO_1	1	L_47	n=2	HP	50*4.0		
		L_48	0	OF	R90.0	4	P+S
CO_2	1	BEGIN	n=2	HP	50*4.0		
		END	0	OF	R90.0	4	P+S

Attachment 10 – BATHMAX 1500 Midship Section: Default Scantlings



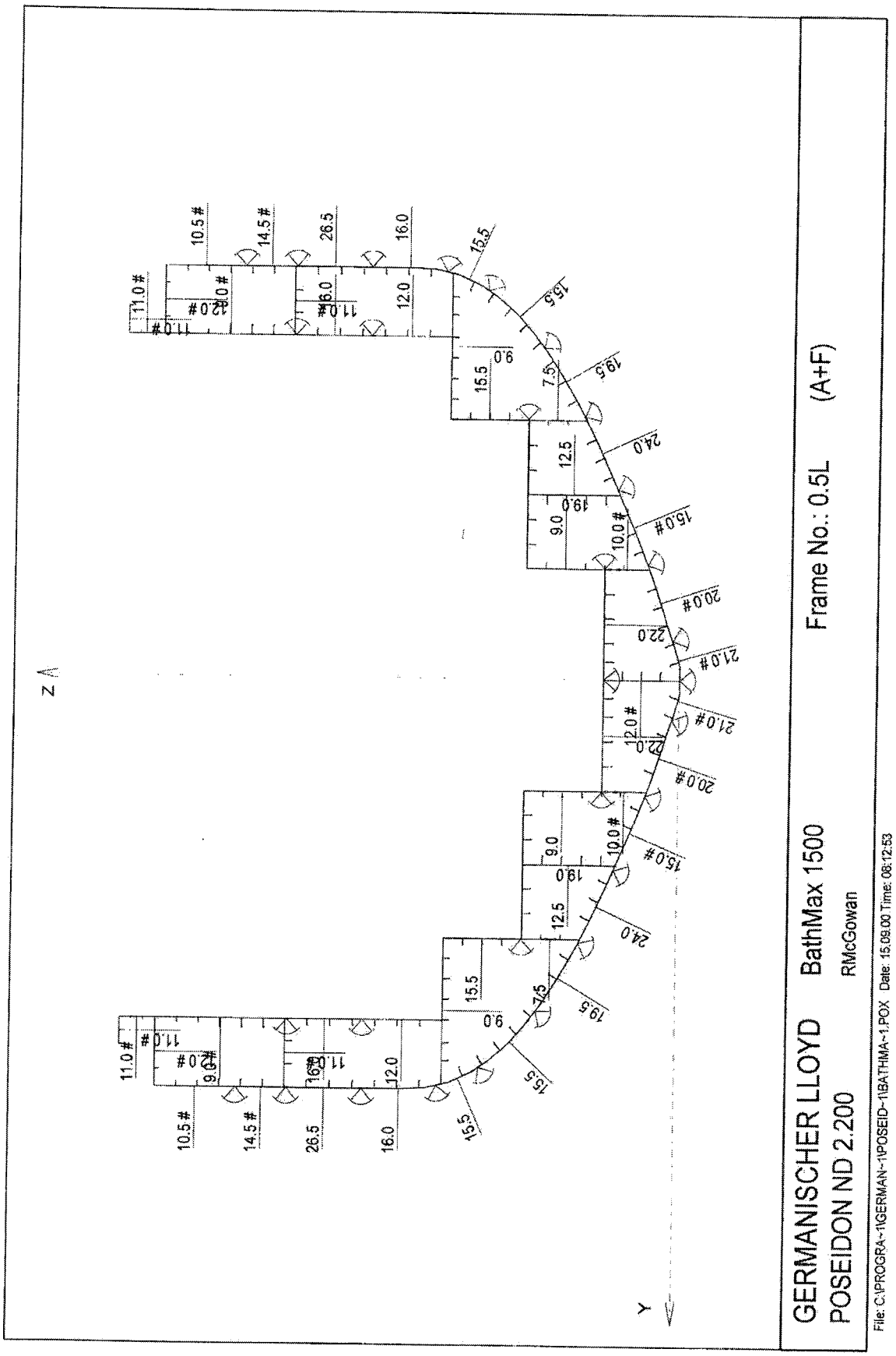
Attachment 11 – BATHMAX 1500 Plate Arrangement: Midship Section – GL Minimum Scantlings

Functional Element / Attributes	Item	Start of Plate / End of Plate	M.Line / t [mm]	Sym. / Mat	Design Criteria
SHELL	A	BEGIN B=1350.0	Right 21.0	P+S 4	S
SHELL	B	AUTO B=2700.0	Right 20.0	P+S 4	S
SHELL	C	AUTO B=2700.0	Right 15.0	P+S 4	S
SHELL	D	AUTO B=2700.0	Right 24.0	P+S 1	S
SHELL	E	AUTO B=2700.0	Right 19.5	P+S 1	S
SHELL	F	AUTO B=2700.0	Right 15.5	P+S 1	S
SHELL	G	AUTO ;Z=8000.0	Right 15.5	P+S 1	S
SHELL	H	AUTO ;Z=10500.0	Right 16.0	P+S 1	S
SHELL	I	AUTO ;Z=13000.0	Right 26.5	P+S 1	S
SHELL	J	AUTO END-2700.0	Right 14.5	P+S 4	S
SHELL	K	AUTO END	Right 10.5	P+S 4	S
CO_1	pl.1	BEGIN END	Right 11.0	P+S 4	CO
CO_2	pl.1	BEGIN END	Right 11.0	P+S 4	CO
DK_1	pl.1	BEGIN END	Right 12.0	P+S 4	WD
DK_2	pl.1	BEGIN END	Right 11.0	P+S 4	WT
DK_4	pl.1	BEGIN END	Right 11.0	P+S 1	WT
DK_5	pl.1	BEGIN END	Right 9.0	P+S 1	WT
DK_6	pl.1	BEGIN END	Right 19.0	P+S 1	IB
LB_0	pl.1	BEGIN END	Right 22.0	P 4	WT
LB_2	pl.1	BEGIN L_24	Right 12.0	P+S 4	
LB_2	pl.2	AUTO END	Right 10.0	P+S 1	WT
LB_3	pl.1	BEGIN END	Right 9.0	P+S 1	WT
LB_4	pl.1	BEGIN L_28	Right 12.5	P+S 1	
LB_4	pl.2	AUTO END	Right 7.5	P+S 1	WT
LB_5	pl.1	BEGIN ;Z=10500.0	Right 15.5	P+S 1	WT
LB_5	pl.2	AUTO ;Z=13000.0	Right 12.0	P+S 1	WT
LB_5	pl.3	AUTO END	Right 9.0	P+S 4	WT

Attachment 12 – BATHMAX 1500 Stiffener Arrangement: Midship Section – GL Minimum Scantlings

Functional Element	Item	Start of Spacing	a [mm]	Type	Dimensions		
Attributes		End of Spacing	l [mm]	M.Line	Rot.	Mat.	Sym.
SHELL	1	L_1	0	HP	300*12.0		
		n=1	0	MF	R90.0	4	P+S
SHELL	2	L_2	n=5	HP	300*12.0		
		L_5	0	MF	R90.0	4	P+S
SHELL	3	L_5	n=5	HP	300*12.0		
		L_8	0	MF	R90.0	4	P+S
SHELL	4	L_8	n=5	HP	320*12.0		
		L_11	0	MF	R90.0	1	P+S
SHELL	5	L_11	n=10	HP	320*12.0		
		L_32	0	MF	R90.0	1	P+S
SHELL	6	L_32+751.4	751	HP	240*12.0		
		L_40-751.4	0	MF	R90.0	1	P+S
SHELL	7	L_41	n=3	HP	240*14.0		
		L_43	0	MF	R90.0	1	P+S
SHELL	8	L_44	n=2	HP	180*9.0		
		L_45	0	MF	R90.0	4	P+S
LB_0	1	L_21	n=3	HP	280*12.0		
		L_23	0	MF	R90.0	4	P
LB_2	1	L_23	0	HP	140*9.0		
		n=1	0	OF	R90.0	4	P+S
LB_2	2	L_24	0	HP	140*9.0		
		n=1	0	OF	R90.0	1	P+S
LB_2	3	L_25	n=3	HP	200*12.0		
		L_27	0	OF	R90.0	1	P+S
LB_3	1	L_24	n=4	HP	300*12.0		
		L_27	0	MF	R90.0	1	P+S
LB_4	1	L_26	n=2	HP	140*9.0		
		L_27	0	MF	R90.0	1	P+S
LB_4	2	L_29	n=3	HP	220*11.0		
		L_31	0	OF	R90.0	1	P+S
LB_5	1	L_32+751.4	751	HP	220*13.0		
		L_40-751.4	0	OF	R90.0	1	P+S
LB_5	2	L_41	n=3	HP	320*12.0		
		L_43	0	OF	R90.0	1	P+S
LB_5	3	L_44	n=2	HP	160*10.0		
		L_45	0	OF	R90.0	4	P+S
DK_1	1	L_16	n=3	HP	140*9.0		
		L_18	0	OF	R90.0	4	P+S
DK_2	1	L_15+766.7	n=2	HP	240*12.0		
		L_19-766.7	0	OF	R90.0	4	P+S
DK_4	3	L_15+766.7	n=2	HP	220*11.0		
		L_19-766.7	0	OF	R90.0	1	P+S
DK_4	1	L_12	n=3	HP	220*11.0		
		L_14	0	OF	R90.0	1	P+S
DK_4	2	L_15	0	HP	220*11.0		
		n=1	0	OF	R90.0	1	P+S
DK_5	1	L_6	n=2	HP	280*12.0		
		L_7	0	OF	R90.0	1	P+S
DK_5	2	L_9	n=2	HP	280*12.0		
		L_10	0	OF	R90.0	1	P+S
DK_6	1	L_1	0	HP	320*12.0		
		n=1	0	OF	R90.0	1	P+S
DK_6	2	L_2	n=3	HP	320*12.0		
		L_4	0	OF	R90.0	1	P+S
CO_1	1	L_47	n=2	HP	80*5.0		
		L_48	0	OF	R90.0	4	P+S
CO_2	1	BEGIN	n=2	HP	120*6.5		
		END	0	OF	R90.0	4	P+S

Attachment 13 – BATHMAX 1500 Midship Section: GL Minimum Scantlings



Attachment 14 – BATHMAX 1500 Still Water Bending Moments and Shear Force

Stillwater: Seagoing Condition				
	Bending Moments BM		Shear Forces SF	
Frame No.	Max [kN*m]	Min [kN*m]	Max [kN]	Min [kN]
0L	0	0	0	0
0.3L	1260000	-697160	36947	-29873
0.7L	1260000	-697160	36947	-29873
1.0L	0	0	0	0

Attachment 15 – BATHMAX 1500 Wave Bending Moments and Shear Forces

User Defined Wave Moments and Shear Forces						
Position		Vertical Bending		Horizontal Bending		Torsion
Frame No.		BM [kN*m]	SF [kN]	BM [kN*m]	SF [kN]	M_{tor} [kN*m]
0.4L	Min	-3500000	-18622	-1016422	-13184	-231975
	Max	2422583	18622	1016422	13184	231975
0.6L	Min	-3500000	-18622	-1016422	-13184	-231975
	max	2422583	18622	1016422	13184	231975

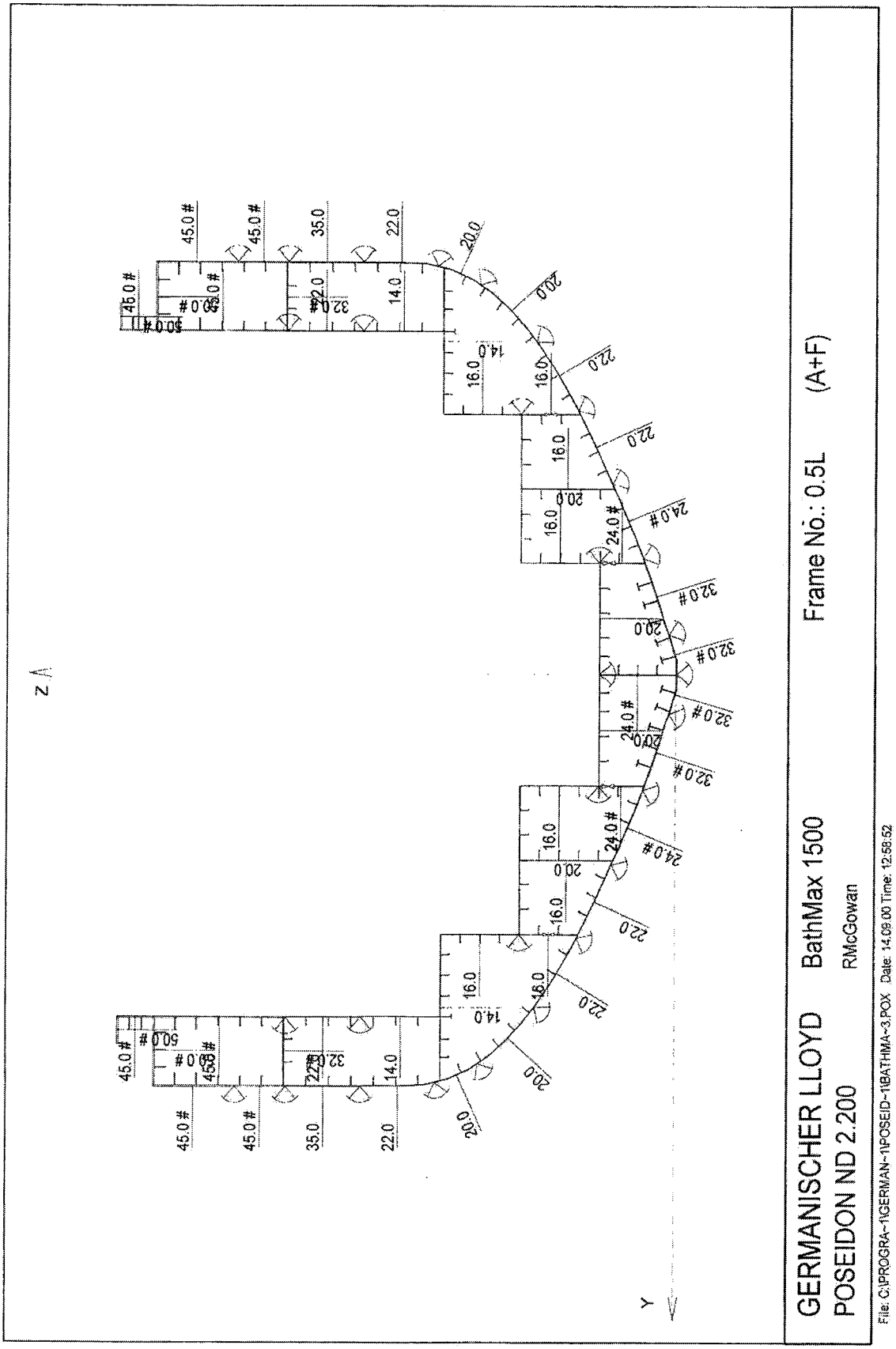
Attachment 16 – BATHMAX 1500 Plate Arrangement: Midship Section – GL Final Scantlings

Functional Element	Item	Start of Plate	M.Line	Sym.	Design Criteria
Attributes		End of Plate	t [mm]	Mat	
SHELL	A	BEGIN B=1350.0	Right 32.0	P+S 4	S
SHELL	B	AUTO B=2700.0	Right 32.0	P+S 4	S
SHELL	C	AUTO B=2700.0	Right 24.0	P+S 4	S
SHELL	D	AUTO B=2700.0	Right 22.0	P+S 1	S
SHELL	E	AUTO B=2700.0	Right 22.0	P+S 1	S
SHELL	F	AUTO B=2700.0	Right 20.0	P+S 1	S
SHELL	G	AUTO ;Z=8000.0	Right 20.0	P+S 1	S
SHELL	H	AUTO ;Z=10500.0	Right 22.0	P+S 1	S
SHELL	I	AUTO ;Z=13000.0	Right 35.0	P+S 1	S
SHELL	J	AUTO END-2700.0	Right 45.0	P+S 4	S
SHELL	K	AUTO END	Right 45.0	P+S 4	S
CO_1	pl.1	BEGIN END	Right 45.0	P+S 4	CO
CO_2	pl.1	BEGIN END	Right 50.0	P+S 4	CO
DK_1	pl.1	BEGIN END	Right 50.0	P+S 4	WD
DK_2	pl.1	BEGIN END	Right 32.0	P+S 4	WT
DK_4	pl.1	BEGIN END	Right 14.0	P+S 1	WT
DK_5	pl.1	BEGIN END	Right 20.0	P+S 1	WT
DK_6	pl.1	BEGIN END	Right 20.0	P+S 1	IB
LB_0	pl.1	BEGIN END	Right 24.0	P 4	WT
LB_2	pl.1	BEGIN L_24	Right 24.0	P+S 4	
LB_2	pl.2	AUTO END	Right 16.0	P+S 1	WT
LB_3	pl.1	BEGIN END	Right 16.0	P+S 1	WT
LB_4	pl.1	BEGIN L_28	Right 16.0	P+S 1	
LB_4	pl.2	AUTO END	Right 16.0	P+S 1	WT
LB_5	pl.1	BEGIN ;Z=10500.0	Right 14.0	P+S 1	WT
LB_5	pl.2	AUTO ;Z=13000.0	Right 22.0	P+S 1	WT
LB_5	pl.3	AUTO END	Right 45.0	P+S 4	WT

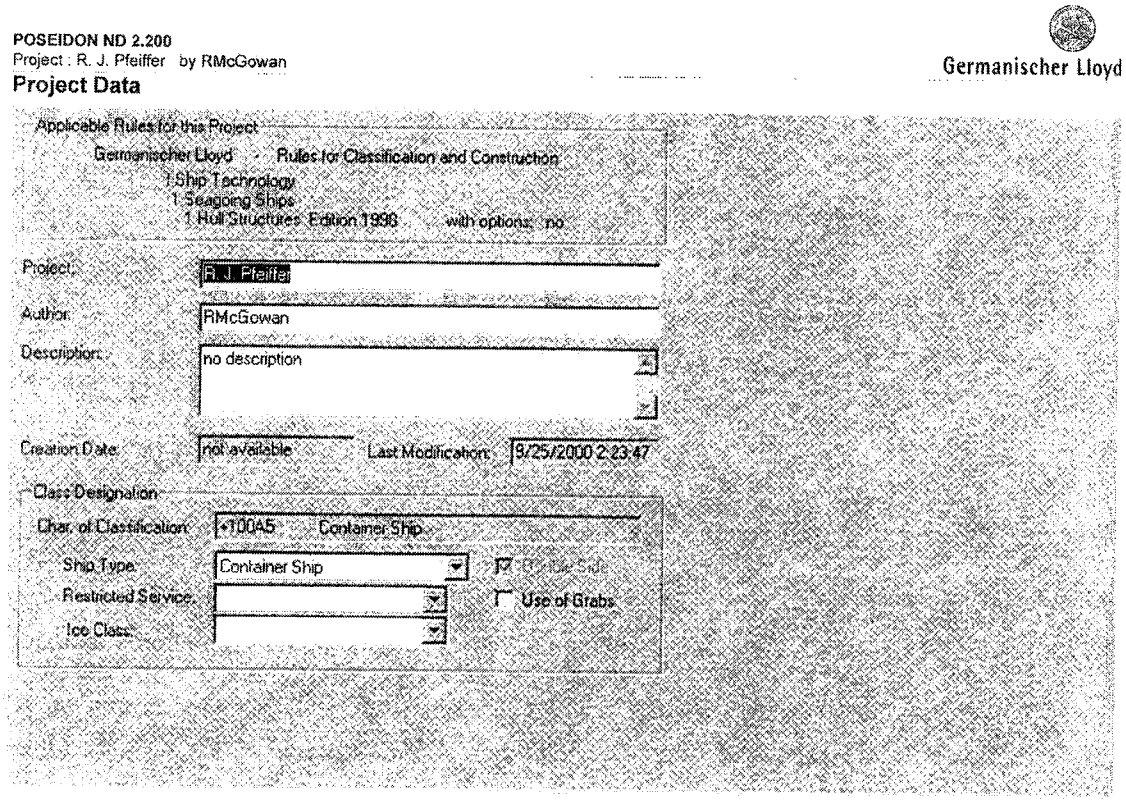
Attachment 17 – BATHMAX 1500 Stiffener Arrangement: Midship Section – GL Final Scantlings

Functional Element	Item	Start of Spacing	a [mm]	Type	Dimensions		
Attributes		End of Spacing	l [mm]	M.Line	Rot.	Mat.	Sym.
SHELL	1	L_1	0	HP	450*20.0*250*30.0		
		n=1	0	MF	R90.0	4	P+S
SHELL	2	L_2	n=5	HP	450*20.0*250*30.0		
		L_5	0	MF	R90.0	4	P+S
SHELL	3	L_5	n=5	HP	320*12.0		
		L_8	0	MF	R90.0	4	P+S
SHELL	4	L_8	n=5	HP	320*12.0		
		L_11	0	MF	R90.0	1	P+S
SHELL	5	L_11	n=10	HP	300*12.0		
		L_32	0	MF	R90.0	1	P+S
SHELL	6	L_32+751.4	751	HP	300*12.0		
		L_40-751.4	0	MF	R90.0	1	P+S
SHELL	7	L_41	n=3	HP	300*12.0		
		L_43	0	MF	R90.0	1	P+S
SHELL	8	L_44	n=2	HP	400*35.0		
		L_45	0	MF	R90.0	4	P+S
LB_0	1	L_21	n=3	HP	320*12.0		
		L_23	0	MF	R90.0	4	P
LB_2	1	L_23	0	HP	320*12.0		
		n=1	0	OF	R90.0	4	P+S
LB_2	2	L_24	0	HP	400*35.0		
		n=1	0	OF	R90.0	1	P+S
LB_2	3	L_25	n=3	HP	320*12.0		
		L_27	0	OF	R90.0	1	P+S
LB_3	1	L_24	n=4	HP	320*12.0		
		L_27	0	MF	R90.0	1	P+S
LB_4	1	L_26	n=2	HP	300*12.0		
		L_27	0	MF	R90.0	1	P+S
LB_4	2	L_29	n=3	HP	280*12.0		
		L_31	0	OF	R90.0	1	P+S
LB_5	1	L_32+751.4	751	HP	280*12.0		
		L_40-751.4	0	OF	R90.0	1	P+S
LB_5	2	L_41	n=3	HP	280*12.0		
		L_43	0	OF	R90.0	1	P+S
LB_5	3	L_44	n=2	HP	400*35.0		
		L_45	0	OF	R90.0	4	P+S
DK_1	1	L_16	n=3	HP	400*35.0		
		L_18	0	OF	R90.0	4	P+S
DK_2	1	L_15+766.7	n=2	HP	280*12.0		
		L_19-766.7	0	OF	R90.0	4	P+S
DK_4	3	L_15+766.7	n=2	HP	280*12.0		
		L_19-766.7	0	OF	R90.0	1	P+S
DK_4	1	L_12	n=3	HP	280*12.0		
		L_14	0	OF	R90.0	1	P+S
DK_4	2	L_15	0	HP	350*10.0*150*12.0		
		n=1	0	OF	R90.0	1	P+S
DK_5	1	L_6	n=2	HP	300*12.0		
		L_7	0	OF	R90.0	1	P+S
DK_5	2	L_9	n=2	HP	300*12.0		
		L_10	0	OF	R90.0	1	P+S
DK_6	1	L_1	0	HP	320*12.0		
		n=1	0	OF	R90.0	1	P+S
DK_6	2	L_2	n=3	HP	320*12.0		
		L_4	0	OF	R90.0	1	P+S
CO_1	1	L_47	n=2	HP	400*35.0		
		L_48	0	OF	R90.0	4	P+S
CO_2	1	BEGIN	n=2	HP	300*20.0		
		END	0	OF	R90.0	4	P+S

Attachment 18 – BATHMAX 1500 Midship Section: GL Final Scantlings



Attachment 19 - R.J. PFEIFFER Project Data



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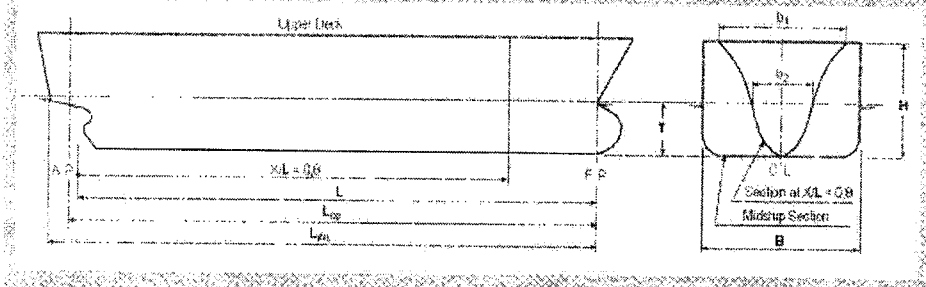
Attachment 20 – R.J. PFEIFFER Principal Dimensions

POSEIDON ND 2.200
Project : R. J. Pfeiffer by RMcGowan

Germanischer Lloyd

Principal Dimensions

Length betw. perpendiculars	Lpp	201.158	m	Block coefficient	CB	0.557	
Length of water line at T	Lwl	207.809	m	Max. speed in calm water	Vo	23.500	kn
Scantling length	L	201.575	m	Min. draught at FP in ballast	Tb	10.516	m
Breath	B	32.207	m	Deadweight		29015.000	tdw
Depth	H	20.269	m	Breath of upper const. Deck at 0.8*L	b1	0.000	m
Scantling draught	T	11.582	m	Breath of waterline at 0.8*L	b2	0.000	m



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Attachment 21 – R.J. PFEIFFER Materials

Material Number	E-Modulus [kN/m^2]	G-Modulus [kN/m^2]	Material Density [kg/mm^2]	Yield Stress [N/mm^2]	Remark
1	206000000	79230769	8000	235	
2	206000000	79230769	8000	315	
3	206000000	79230769	8000	355	
4	206000000	79230769	8000	390	

Attachment 22 – R.J. PFEIFFER Frame Table in X-Direction

Frame No.	Frame Spacing [mm]	M. Line	X_p-Coordinate Fr.aft PP [m]	X/L
0	610	Aft	0	0
16	1372	Aft	9.754	0.031
17	3150	Aft	11.125	0.037
21	1372	Aft	23.724	0.1
22	3150	Aft	25.095	0.107
26	1372	Aft	37.694	0.169
27	3150	Aft	39.065	0.176
31	1372	Aft	51.664	0.239
32	787	Aft	53.035	0.245
53	2184	Aft	69.571	0.327
54	3150	Aft	71.755	0.338
58	1575	Aft	84.353	0.401
59	3150	Aft	85.928	0.409
63	1575	Aft	98.527	0.471
64	3150	Aft	100.101	0.479
68	1575	Aft	112.7	0.541
69	3150	Aft	114.275	0.549
73	1575	Aft	126.873	0.612
74	2565	Aft	128.448	0.619
76	2591	Aft	133.579	0.645
77	1575	Aft	136.169	0.658
78	3175	Aft	137.744	0.666
79	1372	Aft	140.919	0.681
80	3175	Aft	142.291	0.688
81	1575	Aft	145.466	0.704
82	2565	Aft	147.041	0.712
84	2591	Aft	152.171	0.737
85	1372	Aft	154.762	0.75
86	2565	Aft	156.134	0.757
88	2591	Aft	161.265	0.782
89	1372	Aft	163.855	0.795
90	2565	Aft	165.227	0.802
92	2591	Aft	170.358	0.827
93	1372	Aft	172.949	0.84
94	2565	Aft	174.32	0.847
96	2591	Aft	179.451	0.872
97	1372	Aft	182.042	0.885
98	2565	Aft	183.413	0.892
100	2591	Aft	188.544	0.918
101	610	Aft	191.135	0.93
124	610	Aft	205.156	1

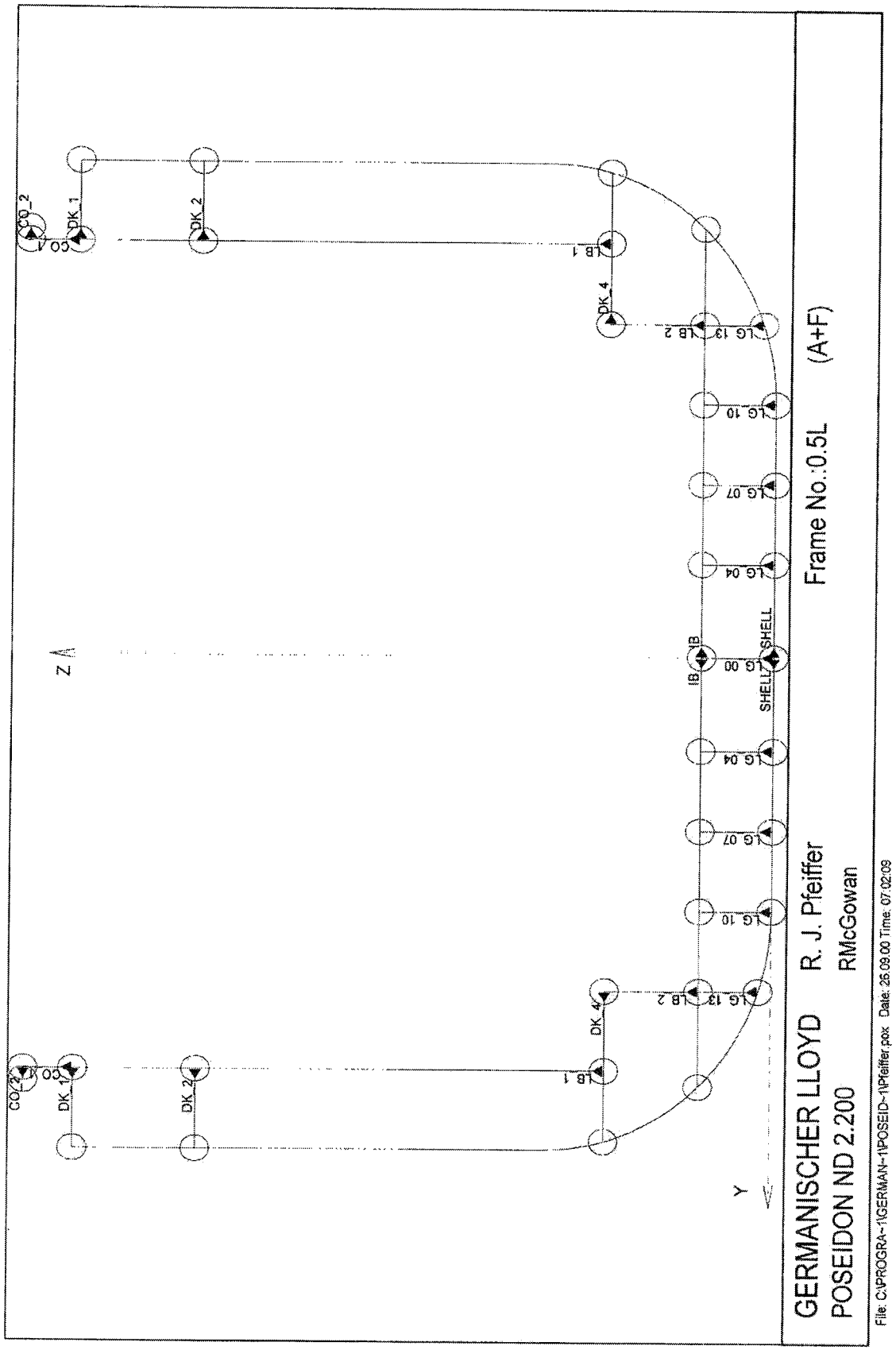
Attachment 23 – R.J. PFEIFFER Frame Table in Y- and Z-Direction

Name	No	Spacing [mm]	Y [mm]	Z [mm]	Frame No.	F/A	Sym
L_0	1	0.0	0.0		0.5L	A+F	P+S
L_1	1	0.0	3048.0		0.5L	A+F	P+S
L_2	1	0.0	5664.2		0.5L	A+F	P+S
L_3	1	0.0	8280.4		0.5L	A+F	P+S
L_4	1	0.0	10896.6		0.5L	A+F	P+S
L_5	1	0.0	13512.8		0.5L	A+F	P+S
L_6	1	0.0	16103.5		0.5L	A+F	P+S
L_10	1	0.0		0.0	0.5L	A+F	P+S
L_11	1	0.0		2082.8	0.5L	A+F	P+S
L_12	1	0.0		4826.0	0.5L	A+F	P+S
L_13	1	0.0		10312.4	0.5L	A+F	P+S
L_14	1	0.0		16713.2	0.5L	A+F	P+S
L_15	1	0.0		20269.2	0.5L	A+F	P+S
L_16	1	0.0		21717.0	0.5L	A+F	P+S

Attachment 24 – R.J. PFEIFFER Shape Representation: Midship Section

Functional Element	Description	Frame No.	F/A	Sym	No.	Y [mm]	Z [mm]	LT
CO_1	Hatch Coaming	0.5L	A+F	P+S	1	L_5	DK_1	3
					2	L_5	L_16	
CO_2	Hatch Coaming	0.5L	A+F	P+S	1	CO_1	L_16	3
					2	CO_1+394	L_16	
DK_1	Main Deck	0.5L	A+F	P+S	1	L_5	L_15	3
					2	SHELL	L_15	
DK_2	Second Deck	0.5L	A+F	P+S	1	LB_1	L_14	3
					2	SHELL	L_14	
DK_4	Fourth Deck	0.5L	A+F	P+S	1	L_4	L_12	3
					2	SHELL	L_12	
IB	Inner Bottom	0.5L	A+F	P+S	1	0.0	L_11	3
					2	SHELL	L_11	
LB_1	Longitudinal Bulkhead at y = 13513	0.5L	A+F	P+S	1	L_5	DK_4	3
					2	L_5	DK_1	
LB_2	Longitudinal Bulkhead at y = 10897	0.5L	A+F			L_4	IB	3
						L_4	DK_4	
LG_00	Longitudinal Girder at y = 0	0.5L	A+F	P	1	L_0	SHELL	3
					2	L_0	IB	
LG_04	Longitudinal Girder at y = 3048	0.5L	A+F	P+S	1	L_1	SHELL	3
					2	L_1	IB	
LG_07	Longitudinal Girder at y = 5664	0.5L	A+F	P+S	1	L_2	SHELL	3
					2	L_2	IB	
LG_10	Longitudinal Girder at y = 8280	0.5L	A+F	P+S	1	L_3	SHELL	3
					2	L_3	IB	
LG_13	Longitudinal Girder at y = 10897	0.5L	A+F	P+S	1	L_4	SHELL	3
					2	L_4	IB	
SHELL	Shell	0.5L	A+F	P+S	1	0.0	0.0	1
					2	8382.0	0.0	1
					3	8953.8	18.0	1
					4	9524.8	72.2	1
					5	10094.2	163.1	1
					6	10660.9	291.9	1
					7	11223.4	459.8	1
					8	11779.6	668.5	1
					9	12326.7	919.7	1
					10	12861.1	1215.2	1
					11	13378.4	1556.8	1
					12	13872.9	1945.8	1
					13	14338.1	2382.7	1
					14	14766.3	2867.2	1
					15	15149.4	3397.5	1
					16	15478.5	3970.3	1
					17	15745.2	4580.2	1
					18	15942.2	5220.1	1
					19	16062.9	5881.2	1
					20	16103.5	6553.2	1
					21	16103.5	L_15	

Attachment 25 – R.J. PFEIFFER Functional Elements: Midship Section



Attachment 26 – R.J. PFEIFFER Plate Arrangement: Midship Section – Default Scantlings

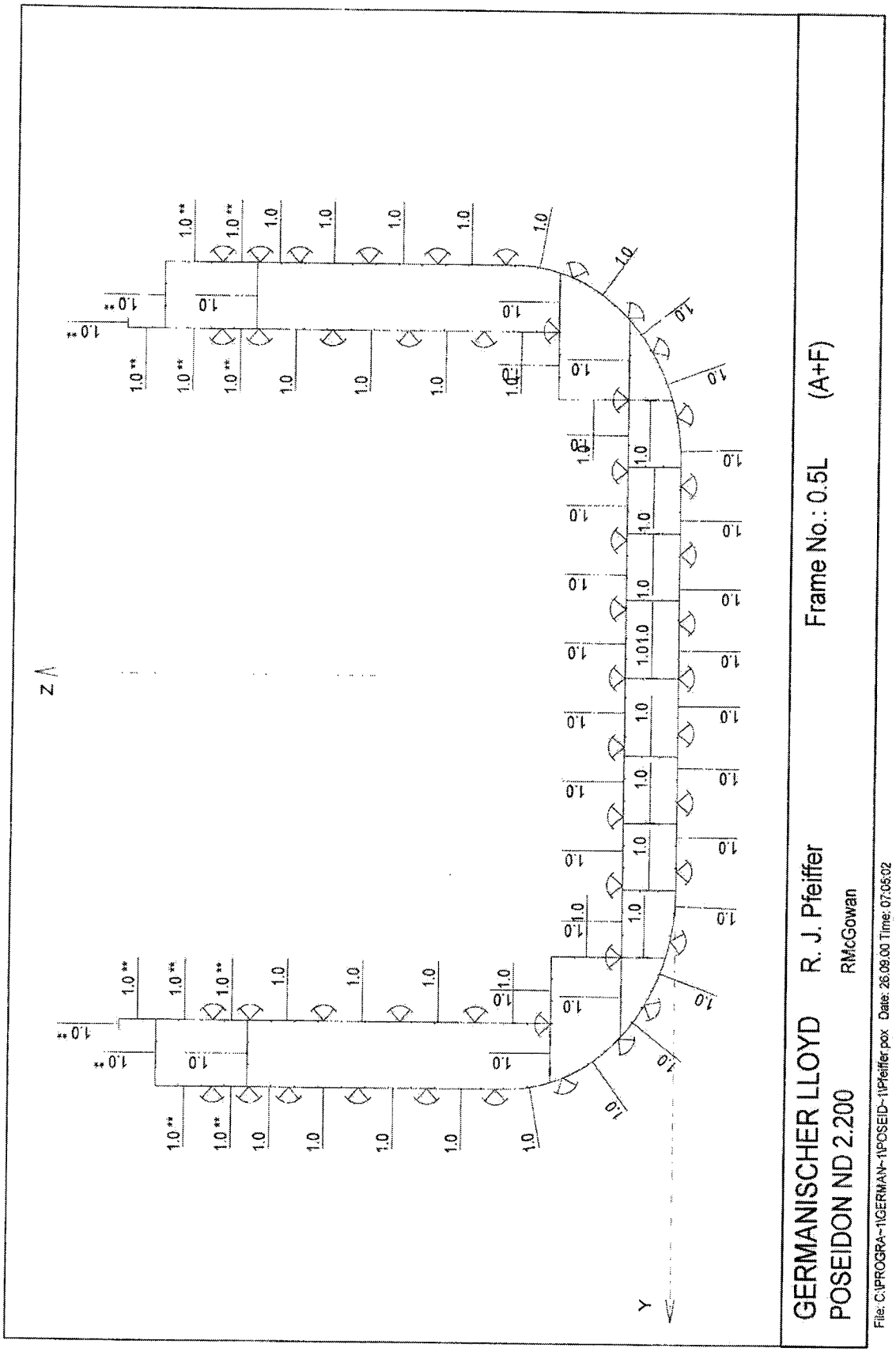
Functional Element	Item	Start of Plate	M.Line	Sym.	Design Criteria
Attributes		End of Plate	t [mm]	Mat	
SHELL	Keel	BEGIN B=2150.0	Right	P+S 1	S
SHELL	A	AUTO B=2700.0	Right	P+S 1	S
SHELL	B	AUTO B=2700.0	Right	P+S 1	S
SHELL	C	AUTO B=2700.0	Right	P+S 1	S
SHELL	D	AUTO B=2700.0	Right	P+S 1	S
SHELL	E	AUTO IB+100.0	Right	P+S 1	S
SHELL	F	AUTO B=2700.0	Right	P+S 1	S
SHELL	G	AUTO B=2700.0	Right	P+S 1	S
SHELL	H	AUTO B=2700.0	Right	P+S 1	S
SHELL	I	AUTO B=2700.0	Right	P+S 1	S
SHELL	J	AUTO B=2700.0	Right	P+S 1	S
SHELL	K	AUTO DK_2-100.0	Right	P+S 1	S
SHELL	L	AUTO END-2222.5	Right	P+S 3	S
SHELL	M	AUTO END	Right	P+S 3	S
IB	pl1	BEGIN B=2700.0	Left	P+S 1	IB
IB	pl2	AUTO B=2700.0	Left	P+S 1	IB
IB	pl3	AUTO B=2700.0	Left	P+S 1	IB
IB	pl4	AUTO Y=10897.0	Left	P+S 1	IB
IB	pl5	AUTO END	Left	P+S 1	IB
DK_1	pl1	BEGIN END	Left	P+S 3	WD
DK_2	pl1	BEGIN END	Left	P+S 1	
DK_4	pl1	BEGIN Y=13563.0	Left	P+S 1	
DK_4	pl2	AUTO END	Left	P+S 1	
LB_1	pl1	BEGIN B=2971.8	Left	P+S 1	
LB_1	pl2	AUTO B=2971.8	Left	P+S 1	
LB_1	pl3	AUTO B=2971.8	Left	P+S 1	
LB_1	pl4	AUTO DK_2-100.0	Left	P+S 1	

Functional Element / Attributes	Item	Start of Plate / End of Plate	M.Line / t [mm]	Sym. / Mat	Design Criteria
LB_1	pl5	AUTO END-2222.5	Left	P+S 3	
LB_1	pl6	AUTO END	Left	P+S 3	
LB_2	pl1	BEGIN END	Left	P+S 1	
LG_00	pl1	BEGIN END	Left	P 1	
LG_13	pl1	BEGIN END	Left	P+S 1	
LG_10	pl1	BEGIN END	Left	P+S 1	
LG_07	pl1	BEGIN END	Left	P+S 1	
LG_04	pl1	BEGIN END	Left	P+S 1	
CO_1	pl1	BEGIN END	Left	P+S 3	CO
CO_2	pl1	BEGIN END	Left	P+S 3	CO

Attachment 27 – R.J. PFEIFFER Stiffener Arrangement: Midship Section – Default Scantlings

Functional Element	Item	Start of Spacing	a [mm]	Type	Dimensions		
Attributes		End of Spacing	l [mm]	M.Line	Rot.	Mat.	Sym.
SHELL	st1	LG_00	n=5	HP			
		LG_04	0	MF	R90.0	3	P+S
SHELL	st5	LG_04	n=4	HP			
		LG_07	0	MF	R90.0	3	P+S
SHELL	st8	LG_07	n=4	HP			
		LG_10	0	MF	R90.0	3	P+S
SHELL	st11	LG_10	n=4	HP			
		LG_13	0	MF	R90.0	3	P+S
SHELL	st14	LG_13	n=6	HP			
		IB	0	MF	R90.0	3	P+S
SHELL	st19	IB	n=5	HP			
		DK_4	0	MF	R90.0	3	P+S
SHELL	st23	DK_4	914	HP			
		n=8	0	MF	R90.0	3	P+S
SHELL	st30	DK_4+7315.2	914	HP			
		n=2	0	MF	R90.0	3	P+S
SHELL	st32	DK_4+9144.0	n=4	HP			
		DK_2	0	MF	R90.0	3	P+S
SHELL	st36	DK_2	n=5	FB			
		DK_1	0	MF	R90.0	3	P+S
IB	st1	LG_00	n=5	HP			
		LG_04	0	MF	R90.0	3	P+S
IB	st5	LG_04	n=4	HP			
		LG_07	0	MF	R90.0	3	P+S
IB	st8	LG_07	n=4	HP			
		LG_10	0	MF	R90.0	3	P+S
IB	st11	LG_10	n=4	HP			
		LG_13	0	MF	R90.0	3	P+S
IB	st14	LG_13	871	HP			
		n=4	0	MF	R90.0	3	P+S
DK_1	st1	LB_1+863.6	863	FB			
		END	0	MF	R90.0	3	P+S
DK_2	st1	LB_1+863.6	863	HP			
		END	0	MF	R90.0	3	P+S
DK_4	st1	LB_2	871	HP			
		n=3	0	MF	R90.0	3	P+S
DK_4	st3	LB_1	0	HP			
		n=1	0	MF	R90.0	3	P+S
LB_1	st1	DK_4	914	HP			
		n=8	0	MF	R90.0	3	P+S
LB_1	st8	DK_4+7315.2	914	HP			
		n=2	0	MF	R90.0	3	P+S
LB_1	st10	DK_4+9144.0	n=4	HP			
		DK_2	0	MF	R90.0	3	P+S
LB_1	st13	DK_2	n=5	FB			
		DK_1	0	MF	R90.0	3	P+S
LB_2	st1	IB	n=4	HP			
		DK_4	0	MF	R90.0	3	P+S
CO_1	st1	DK_1+482.6	482	FB			
		n=2	0	MR	R90.0	3	P+S
LG_00	st1	BEGIN	n=4	HP			
		END	0	MF	R90.0	3	P
LG_04	st1	BEGIN	n=4	HP			
		END	0	MF	R90.0	3	P+S
LG_07	st1	BEGIN	n=4	FB			
		END	0	MF	R90.0	3	P+S
LG_10	st1	BEGIN	n=4	HP			
		END	0	MF	R90.0	3	P+S
LG_13	st1	BEGIN	n=4	FB			
		END	0	MF	R90.0	3	P+S

Attachment 28 – R.J. PFEIFFER Midship Section – Default Scantlings



Attachment 29 – R.J. PFEIFFER Plate Arrangement: Midship Section – GL Minimum Scantlings

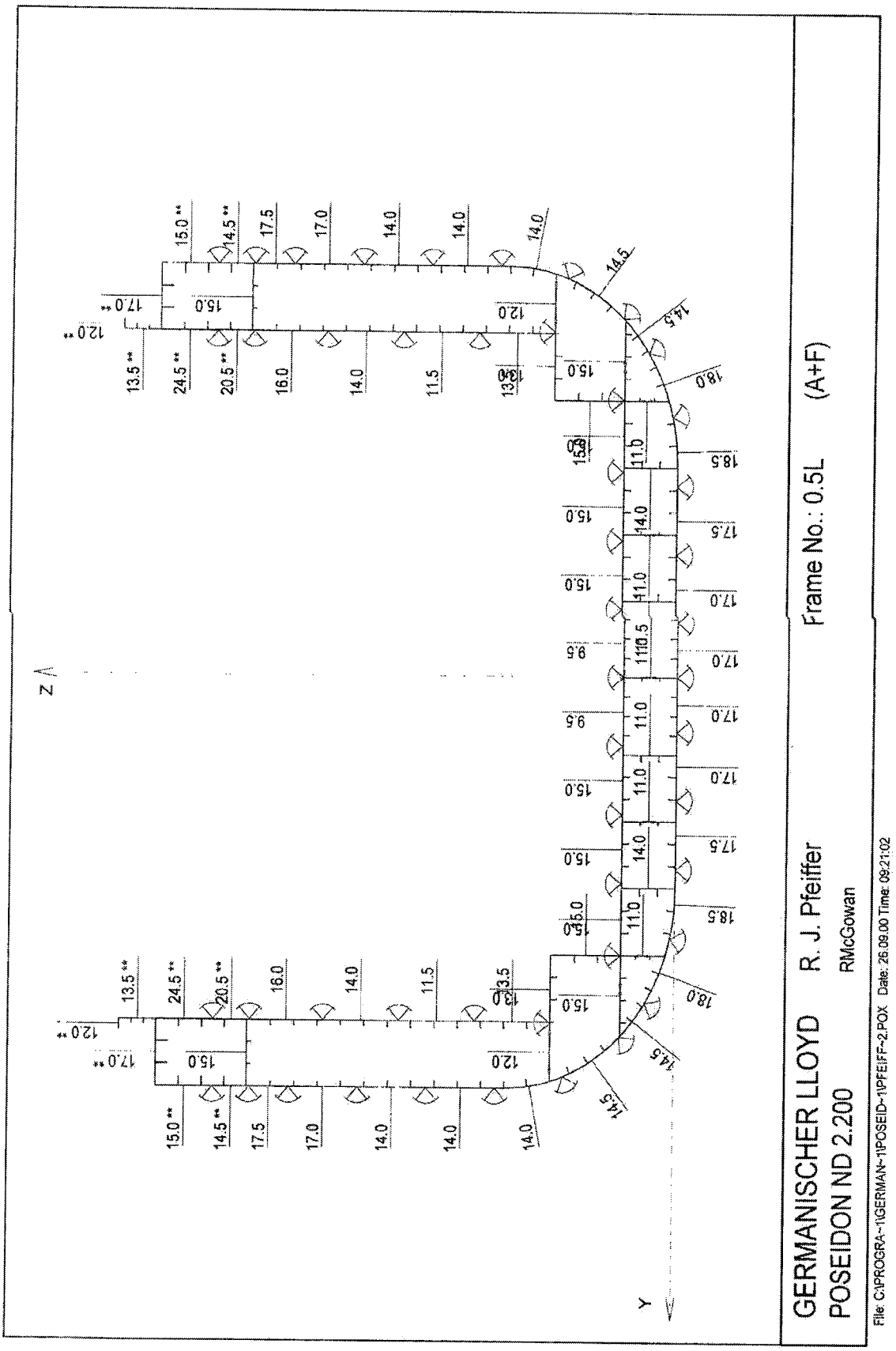
Functional Element	Item	Start of Plate	M.Line	Sym.	Design Criteria
Attributes		End of Plate	t [mm]	Mat	
SHELL	Keel	BEGIN B=2150.0	Right 17	P+S 1	S
SHELL	A	AUTO B=2700.0	Right 17	P+S 1	S
SHELL	B	AUTO B=2700.0	Right 17.5	P+S 1	S
SHELL	C	AUTO B=2700.0	Right 18.5	P+S 1	S
SHELL	D	AUTO B=2700.0	Right 18	P+S 1	S
SHELL	E	AUTO IB+100.0	Right 14.5	P+S 1	S
SHELL	F	AUTO B=2700.0	Right 14.5	P+S 1	S
SHELL	G	AUTO B=2700.0	Right 14	P+S 1	S
SHELL	H	AUTO B=2700.0	Right 14	P+S 1	S
SHELL	I	AUTO B=2700.0	Right 14	P+S 1	S
SHELL	J	AUTO B=2700.0	Right 17	P+S 1	S
SHELL	K	AUTO DK_2-100.0	Right 17.5	P+S 1	S
SHELL	L	AUTO END-2222.5	Right 14.5	P+S 3	S
SHELL	M	AUTO END	Right 15	P+S 3	S
IB	pl1	BEGIN B=2700.0	Left 9.5	P+S 1	IB
IB	pl2	AUTO B=2700.0	Left 15	P+S 1	IB
IB	pl3	AUTO B=2700.0	Left 15	P+S 1	IB
IB	pl4	AUTO Y=10897.0	Left 15	P+S 1	IB
IB	pl5	AUTO END	Left 15	P+S 1	IB
DK_1	pl1	BEGIN END	Left 17	P+S 3	WD
DK_2	pl1	BEGIN END	Left 15	P+S 1	
DK_4	pl1	BEGIN Y=13563.0	Left 13	P+S 1	
DK_4	pl2	AUTO END	Left 12	P+S 1	
LB_1	pl1	BEGIN B=2971.8	Left 13.5	P+S 1	
LB_1	pl2	AUTO B=2971.8	Left 11.5	P+S 1	
LB_1	pl3	AUTO B=2971.8	Left 14	P+S 1	
LB_1	pl4	AUTO DK_2-100.0	Left 16	P+S 1	

Functional Element Attributes	Item	Start of Plate End of Plate	M.Line t [mm]	Sym. Mat	Design Criteria
LB_1	pl5	AUTO END-2222.5	Left 20.5	P+S 3	
LB_1	pl6	AUTO END	Left 24.5	P+S 3	
LB_2	pl1	BEGIN END	Left 15	P+S 1	
LG_00	pl1	BEGIN END	Left 11.5	P 1	
LG_13	pl1	BEGIN END	Left 11	P+S 1	
LG_10	pl1	BEGIN END	Left 14	P+S 1	
LG_07	pl1	BEGIN END	Left 11	P+S 1	
LG_04	pl1	BEGIN END	Left 11	P+S 1	
CO_1	pl1	BEGIN END	Left 13.5	P+S 3	CO
CO_2	pl1	BEGIN END	Left 12	P+S 3	CO

Attachment 30 – R.J. PFEIFFER Stiffener Arrangement: Midship Section – GL Minimum Scantlings

Functional Element	Item	Start of Spacing	a [mm]	Type	Dimensions		
Attributes		End of Spacing	l [mm]	M.Line	Rot.	Mat.	Sym.
SHELL	st1	LG_00	n=5	HP	260*10.0		
		LG_04	0	MF	R90.0	3	P+S
SHELL	st5	LG_04	n=4	HP	280*11.0		
		LG_07	0	MF	R90.0	3	P+S
SHELL	st8	LG_07	n=4	HP	280*11.0		
		LG_10	0	MF	R90.0	3	P+S
SHELL	st11	LG_10	n=4	HP	280*11.0		
		LG_13	0	MF	R90.0	3	P+S
SHELL	st14	LG_13	n=6	HP	260*10.0		
		IB	0	MF	R90.0	3	P+S
SHELL	st19	IB	n=5	HP	260*11.0		
		DK_4	0	MF	R90.0	3	P+S
SHELL	st23	DK_4	914	HP	260*10.0		
		n=8	0	MF	R90.0	3	P+S
SHELL	st30	DK_4+7315.2	914	HP	200*11.0		
		n=2	0	MF	R90.0	3	P+S
SHELL	st32	DK_4+9144.0	n=4	HP	200*9.0		
		DK_2	0	MF	R90.0	3	P+S
SHELL	st36	DK_2	n=5	FB	380*22.0		
		DK_1	0	MF	R90.0	3	P+S
IB	st1	LG_00	n=5	HP	220*10.0		
		LG_04	0	MF	R90.0	3	P+S
IB	st5	LG_04	n=4	HP	260*12.0		
		LG_07	0	MF	R90.0	3	P+S
IB	st8	LG_07	n=4	HP	260*12.0		
		LG_10	0	MF	R90.0	3	P+S
IB	st11	LG_10	n=4	HP	280*11.0		
		LG_13	0	MF	R90.0	3	P+S
IB	st14	LG_13	871	HP	220*11.0		
		n=4	0	MF	R90.0	3	P+S
DK_1	st1	LB_1+863.6	863	FB	460*32.0		
		END	0	MF	R90.0	3	P+S
DK_2	st1	LB_1+863.6	863	HP	180*10.0		
		END	0	MF	R90.0	3	P+S
DK_4	st1	LB_2	871	HP	260*11.0		
		n=3	0	MF	R90.0	3	P+S
DK_4	st3	LB_1	0	HP	140*9.0		
		n=1	0	MF	R90.0	3	P+S
LB_1	st1	DK_4	914	HP	260*10.0		
		n=8	0	MF	R90.0	3	P+S
LB_1	st8	DK_4+7315.2	914	HP	200*11.0		
		n=2	0	MF	R90.0	3	P+S
LB_1	st10	DK_4+9144.0	n=4	HP	200*9.0		
		DK_2	0	MF	R90.0	3	P+S
LB_1	st13	DK_2	n=5	FB	300*17.0		
		DK_1	0	MF	R90.0	3	P+S
LB_2	st1	IB	n=4	HP	280*11.0		
		DK_4	0	MF	R90.0	3	P+S
CO_1	st1	DK_1+482.6	482	FB	180*14.0		
		n=2	0	MR	R90.0	3	P+S
LG_00	st1	BEGIN	n=4	HP	140*6.0		
		END	0	MF	R90.0	3	P
LG_04	st1	BEGIN	n=4	HP	260*10.0		
		END	0	MF	R90.0	3	P+S
LG_07	st1	BEGIN	n=4	FB	140*10.0		
		END	0	MF	R90.0	3	P+S
LG_10	st1	BEGIN	n=4	HP	280*11.0		
		END	0	MF	R90.0	3	P+S
LG_13	st1	BEGIN	n=4	FB	130*10.0		
		END	0	MF	R90.0	3	P+S

Attachment 31 – R.J. PFEIFFER Midship Section: GL Minimum Scantlings



Attachment 32 – R.J. PFEIFFER Still Water Bending Moments and Shear Forces

Stillwater: Seagoing Condition				
	Bending Moments BM		Shear Forces SF	
Frame No.	Max [kN*m]	Min [kN*m]	Max [kN]	Min [kN]
0L	0	0	0	0
0.3L	1960766	-1317970	32616	-27787
0.7L	1960766	-1317970	32616	-27787
1.0L	0	0	0	0

Attachment 33 – R.J. PFEIFFER Plate Arrangement: Midship Section – GL Final Scantlings

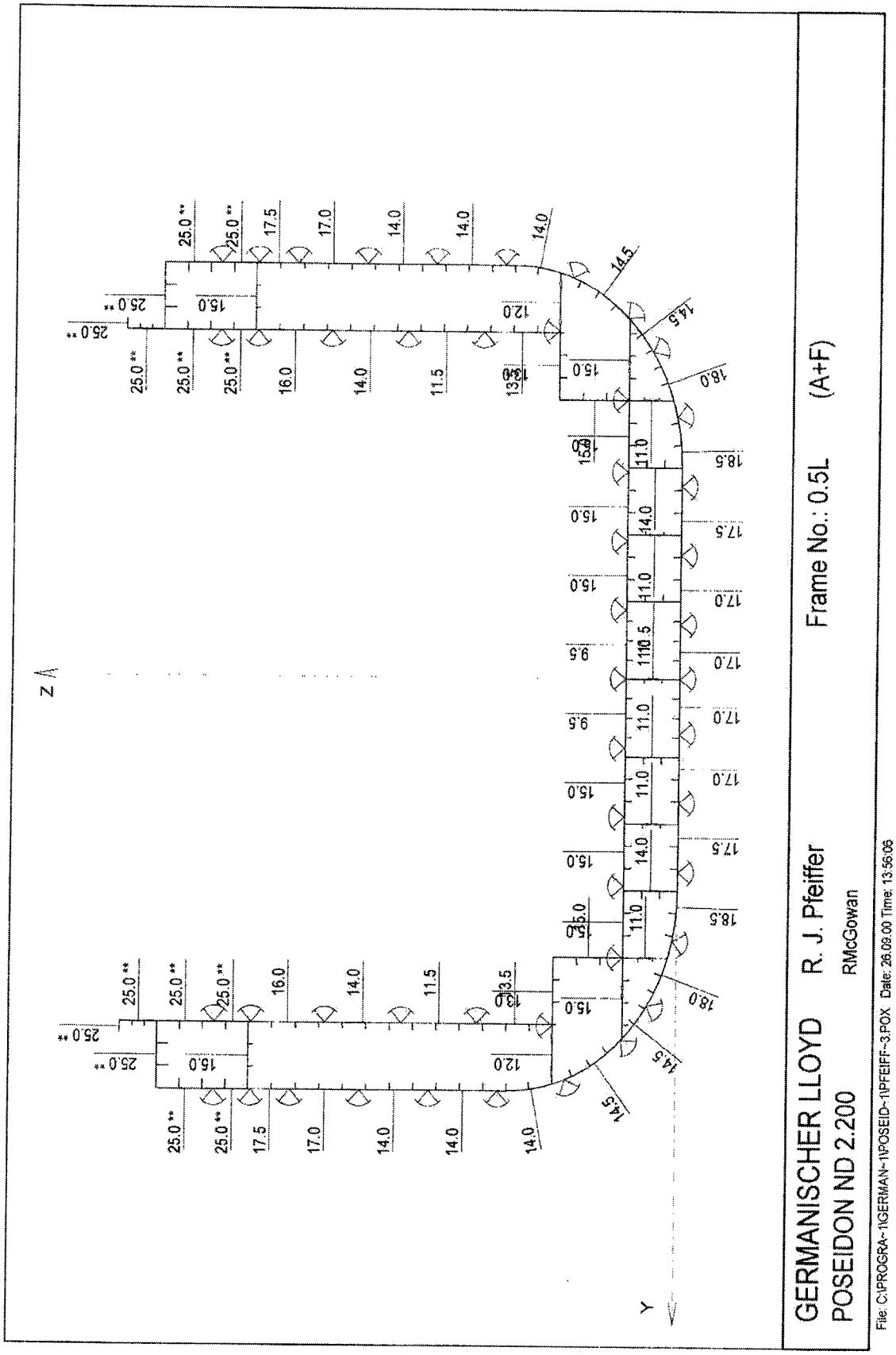
Functional Element / Attributes	Item	Start of Plate / End of Plate	M.Line / t [mm]	Sym. / Mat	Design Criteria
SHELL	Keel	BEGIN B=2150.0	Right 17	P+S 1	S
SHELL	A	AUTO B=2700.0	Right 17	P+S 1	S
SHELL	B	AUTO B=2700.0	Right 17.5	P+S 1	S
SHELL	C	AUTO B=2700.0	Right 18.5	P+S 1	S
SHELL	D	AUTO B=2700.0	Right 18	P+S 1	S
SHELL	E	AUTO IB+100.0	Right 14.5	P+S 1	S
SHELL	F	AUTO B=2700.0	Right 14.5	P+S 1	S
SHELL	G	AUTO B=2700.0	Right 14	P+S 1	S
SHELL	H	AUTO B=2700.0	Right 14	P+S 1	S
SHELL	I	AUTO B=2700.0	Right 14	P+S 1	S
SHELL	J	AUTO B=2700.0	Right 17	P+S 1	S
SHELL	K	AUTO DK_2-100.0	Right 17.5	P+S 1	S
SHELL	L	AUTO END-2222.5	Right 25	P+S 3	S
SHELL	M	AUTO END	Right 25	P+S 3	S
IB	pl1	BEGIN B=2700.0	Left 9.5	P+S 1	IB
IB	pl2	AUTO B=2700.0	Left 15	P+S 1	IB
IB	pl3	AUTO B=2700.0	Left 15	P+S 1	IB
IB	pl4	AUTO Y=10897.0	Left 15	P+S 1	IB
IB	pl5	AUTO END	Left 15	P+S 1	IB
DK_1	pl1	BEGIN END	Left 25	P+S 3	WD
DK_2	pl1	BEGIN END	Left 15	P+S 1	
DK_4	pl1	BEGIN Y=13563.0	Left 13	P+S 1	
DK_4	pl2	AUTO END	Left 12	P+S 1	
LB_1	pl1	BEGIN B=2971.8	Left 13.5	P+S 1	
LB_1	pl2	AUTO B=2971.8	Left 11.5	P+S 1	
LB_1	pl3	AUTO B=2971.8	Left 14	P+S 1	
LB_1	pl4	AUTO DK_2-100.0	Left 16	P+S 1	

Functional Element Attributes	Item	Start of Plate End of Plate	M.Line t [mm]	Sym. Mat	Design Criteria
LB_1	pl5	AUTO END-2222.5	Left 25	P+S 3	
LB_1	pl6	AUTO END	Left 25	P+S 3	
LB_2	pl1	BEGIN END	Left 15	P+S 1	
LG_00	pl1	BEGIN END	Left 11.5	P 1	
LG_13	pl1	BEGIN END	Left 11	P+S 1	
LG_10	pl1	BEGIN END	Left 14	P+S 1	
LG_07	pl1	BEGIN END	Left 11	P+S 1	
LG_04	pl1	BEGIN END	Left 11	P+S 1	
CO_1	pl1	BEGIN END	Left 25	P+S 3	CO
CO_2	pl1	BEGIN END	Left 25	P+S 3	CO

Attachment 34 – R.J. PFEIFFER Stiffener Arrangement: Midship Section – GL Final Scantlings

Functional Element	Item	Start of Spacing	a [mm]	Type	Dimensions		
Attributes		End of Spacing	l [mm]	M.Line	Rot.	Mat.	Sym.
SHELL	st1	LG_00	n=5	HP	260*10.0		
		LG_04	0	MF	R90.0	3	P+S
SHELL	st5	LG_04	n=4	HP	280*11.0		
		LG_07	0	MF	R90.0	3	P+S
SHELL	st8	LG_07	n=4	HP	280*11.0		
		LG_10	0	MF	R90.0	3	P+S
SHELL	st11	LG_10	n=4	HP	280*11.0		
		LG_13	0	MF	R90.0	3	P+S
SHELL	st14	LG_13	n=6	HP	260*10.0		
		IB	0	MF	R90.0	3	P+S
SHELL	st19	IB	n=5	HP	260*11.0		
		DK_4	0	MF	R90.0	3	P+S
SHELL	st23	DK_4	914	HP	260*10.0		
		n=8	0	MF	R90.0	3	P+S
SHELL	st30	DK_4+7315.2	914	HP	200*11.0		
		n=2	0	MF	R90.0	3	P+S
SHELL	st32	DK_4+9144.0	n=4	HP	200*9.0		
		DK_2	0	MF	R90.0	3	P+S
SHELL	st36	DK_2	n=5	FB	380*22.0		
		DK_1	0	MF	R90.0	3	P+S
IB	st1	LG_00	n=5	HP	220*10.0		
		LG_04	0	MF	R90.0	3	P+S
IB	st5	LG_04	n=4	HP	260*12.0		
		LG_07	0	MF	R90.0	3	P+S
IB	st8	LG_07	n=4	HP	260*12.0		
		LG_10	0	MF	R90.0	3	P+S
IB	st11	LG_10	n=4	HP	280*11.0		
		LG_13	0	MF	R90.0	3	P+S
IB	st14	LG_13	871	HP	220*11.0		
		n=4	0	MF	R90.0	3	P+S
DK_1	st1	LB_1+863.6	863	FB	460*32.0		
		END	0	MF	R90.0	3	P+S
DK_2	st1	LB_1+863.6	863	HP	180*10.0		
		END	0	MF	R90.0	3	P+S
DK_4	st1	LB_2	871	HP	260*11.0		
		n=3	0	MF	R90.0	3	P+S
DK_4	st3	LB_1	0	HP	140*9.0		
		n=1	0	MF	R90.0	3	P+S
LB_1	st1	DK_4	914	HP	260*10.0		
		n=8	0	MF	R90.0	3	P+S
LB_1	st8	DK_4+7315.2	914	HP	200*11.0		
		n=2	0	MF	R90.0	3	P+S
LB_1	st10	DK_4+9144.0	n=4	HP	200*9.0		
		DK_2	0	MF	R90.0	3	P+S
LB_1	st13	DK_2	n=5	FB	300*17.0		
		DK_1	0	MF	R90.0	3	P+S
LB_2	st1	IB	n=4	HP	280*11.0		
		DK_4	0	MF	R90.0	3	P+S
CO_1	st1	DK_1+482.6	482	FB	180*14.0		
		n=2	0	MR	R90.0	3	P+S
LG_00	st1	BEGIN	n=4	HP	140*6.0		
		END	0	MF	R90.0	3	P
LG_04	st1	BEGIN	n=4	HP	260*10.0		
		END	0	MF	R90.0	3	P+S
LG_07	st1	BEGIN	n=4	FB	140*10.0		
		END	0	MF	R90.0	3	P+S
LG_10	st1	BEGIN	n=4	HP	280*11.0		
		END	0	MF	R90.0	3	P+S
LG_13	st1	BEGIN	n=4	FB	130*10.0		
		END	0	MF	R90.0	3	P+S

Attachment 35 – R.J. PFEIFFER Midship Section: GL Final Scantlings



11.0 APPENDIX 2

This appendix includes the tables for the qualitative and regulatory analyses:

- SWBS Group 100 – Hull Structure
- SWBS Group 200 – Propulsion Plant
- SWBS Group 300 – Electric Plant
- SWBS Group 400 – Command and Surveillance
- SWBS Group 500 – Auxiliary Systems
- SWBS Group 600 – Outfit and Furnishings
- Regulatory Analysis – Safety Indices
- Regulatory Analysis – Comparison Level Analysis
- U.S. Navy Ship Work Breakdown Structure (SWBS)

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
100	***HULL STRUCTURE, GENERAL***			LR will refer to specific ship types for the midship region.		Except as noted for LR all societies have generic rules and make exceptions for specific types of Ships.
101	GENERAL ARRANGEMENTS - STRUCTURAL DRAWINGS	None Found	Part 3.1-1 C100	Part 3,1,5.2	**None Found**	No List of Required Plans found for ABS or NK.
110	***SHELL AND SUPPORTING STRUCTURE***	Part 3-2-2	Part 3-1.7 C	Part 3,5,3 & 3,6,3 & Part 4(1,5 & 2,4 & 4,3 & 5,3 & 6,5 & 7,5 & 8,5 & 9,4 & 11,4 & 12,4 & 12,4 &	**Pt C, Ch 5,6,16:**	LR - Part 3 has different rules for fore and aft ends of the ship. Part 4 has specific rules by Ship Type. ABS & DNV have all the rules for plating in one section.
111	SHELL PLATING, SURF. SHIP AND SUBMARINE PRESS. HULL	**Pt 3, Ch 2, Sec 2/3.13:** Different formulas for different lengths. Main Variables include: stiffener spacing, LBP, depth, & Draft.	**Pt 3, Ch 1, Sec 6 C300:** Has different formulas for pressure to account for internal pressure from cargo. Main Variables Include: Pressure, Factor for Plate Aspect Ratio, Stiffener Spacing, Allowable Stress, & Corrosion Margin.	**Pt 3:** All Chapters have a section on plating each relating to a different type of Ship. Most chapters refer back to Chapter 1; main variables include: stiff. Spacing, LBP, stress factor, material factor.	**Pt C, Ch 16.3:** Distinguishes between Longitudinally and Transversely Framed Ships, Variables: Spacing of Frames, Length Coefficient, LBP, Cb factor, depth, draft, 2nd Coefficient.	
112	SHELL PLATING, SUBMARINE NON-PRESSURE HULL	Not Applicable to Commercial Surface Ship Construction				
113	INNER BOTTOM	**Part 3-2-4/9:** Main variables include: LBP, frame spacing, margin.	**Part 3-1.6 C400:** Same variables as SWBS 111, except that the formulas for allowable stress and Pressure are different.	**Part 3(5,5 & 6,5) Part 4(1,7 & 1,8 & 2,6 & 5,5 & 6,9 & 7,8 & 8,7 & 9,6 & 11,6 & 12,6):** Main variables include: stiffener spacing, LBP, Draft, material factor.	**Pt C, Ch 6.5:** Variables: Stiff. Spacing, depth, height of center girders, distance between floors.	LR has special rules for different types of ships as well as for the forward and aft portions of the ship.
114	SHELL APPENDAGES	Part 3-2-2/13	Part 3-3	None Found	**Pt C, Ch 3:**	No specific rules for appendages found in LR.
115	STANCHIONS	None Found	None Found	None Found	**Pt C, Ch 11:**	No Significant Difference
116	LONGITUDINAL FRAMING	**Part 3-2-5:** Variables: spacing of longitudinal frames, vertical distance to freeboard deck, unsupported span.	**Part 3-1.6:** Section Modulus Calculation, Typical Variables Include: frame spacing, stiff. Spacing, pressure, section modulus corrosion factor, allowable stress.	**Part 3,(5,5.3 & 5,6.4 & 5,7.4 & 6,5.3 & 6,6.3); Part 4,(1,6 & 2,5 & 5,4.3 & 7,6 & 9,5 & 10,2 & 11,5.3 & 12,5 & 12,6):** Variables: stiffener spacing, material factor, draught, Length, fatigue factor.	**Pt C, Ch 5,6.4,7.4:** Variables include: spacing of longitudinals, distance between web frames, & vertical distance of the side longitudinal.	LR has special rules for different types of ships as well as for the forward and aft portions of the ship.

117	TRANSVERSE FRAMING	**Part 3-2-5:** Variables: spacing of longitudinal frames, vertical distance to load line, horiz. Dist. to deck supports, vertical dist. to the freeboard deck, unsupported span.	**Part 3-1.6 C600:** Section modulus Calculation, Typical Variables are the same as for Longitudinal Framing with the exception of allowable stress which is replaced by a material factor.	**Part 3,(5,5.2 & 5,6.3 & 5,7.3 & 6,5.2 & 6,6.2); Part 4,(1,6 & 2,5 & 4,4.1 & 5,4.4 & 6,6.1 & 7,6 & 8,6 & 9,5.9 & 10,2 & 12,5.2 & 12,6):** Variables: stiffener spacing, material factor, draught, head, Length, vertical framing depth, Inertia Requirement also	**Pt C, Ch 7.3:** Main variables include: Frame Spacing, vertical dist. From the top of inner bottom plate to top of deck beams, height of tank side bracket.	LR has special rules for different types of ships as well as for the forward and aft portions of the ship.
118	LONGITUDINAL. AND TRANSV. SUBMARINE NON-PRESS. HULL FRAMING	Not Applicable to Commercial Surface Ship Construction				N/A
119	LIFT SYSTEM FLEXIBLE SKIRTS AND SEALS	None Found	None Found	None Found	**None Found**	No Significant Difference
120	***HULL STRUCTURAL BULKHEADS***	Part 3-2-9	Part 3-1.9	Part 3,(3,4 & 5,6.(6-7) & 5,7.(5-6) & 6,6.(4-5)); Part 4,(1,9 & 2,7 & 4,7 & 5,7 & 6,7 & 7,(7&9-10) & 9,8 & 9,11.4 & 9,11.5 & 10,(4-5) & 12,9)	**Pt C, Ch 4,11.3,13:**	LR has special rules for different types of ships as well as for the forward and aft portions of the ship.
121	LONGITUDINAL STRUCTURAL BULKHEADS	**None Found**	**Part 3-1.9:** Rules are the same for transverse and long. The variables for plate are: pressure, allowable stress, corrosion addition, stiffener spacing, aspect ratio. The variables for stiffeners are: stiff spacing, frame spacing, pressure, allowable stress	**Part 3,(3,4 & 5,6.(6-7) & 5,7.5 & 6,6.(4-5)); Part 4,(1,9 & 2,7 & 4,7 & 7,(7&9-10) & 8,8 & 9,8 & 9,11.4 & 9,11.5 & 10,(4-5) & 11,7 & 12,9):** Plate Thickness: spacing of secondary stiff., spacing of primary stiff., density of liquid, head strength factor. S	**Pt C, Ch 11.3:** If provided to support a deck in lieu of longitudinal deck girders then it must meet the requirements of pillars. Pillars have a sectional area and thickness requirement.	LR has special rules for different types of ships as well as for the forward and aft portions of the ship.
122	TRANS STRUCTURAL BULKHEADS	**Part 3-2-9:** Rules for plating and stiffeners; Plate thickness: stiff. Spacing, aspect ratio, yield strength, dist. From lower edge of plate to deepest waterline. Stiffener Variables: distance between horizontal girders.		**Part 3,(3,4 & 5,6.(6-7) & 5,7.(5-6) & 6,6.(4-5)); Part 4,(1,9 & 2,7 & 4,7 & 5,7 & 6,7 & 7,(7&9-10) & 8,9 & 9,(7-8) & 9,11.(4-6) & 10,(4-5) & 11,8 & 12,9):** Plate Thickness: spacing of secondary stiff., spacing of primary stiff., density of liquid, head str	**Pt C, Ch 4,13:** Requirements for watertight bulkheads. Scantlings use stiffener span and spacing as well as head.	LR has special rules for different types of ships as well as for the forward and aft portions of the ship.
123	TRUNKS AND ENCLOSURES	None Found	None Found	None Found	None Found	No Significant Difference
124	BULKHEADS IN TORPEDO PROTECTION SYSTEM	Not Applicable to Commercial Surface Ship Construction				N/A
125	SUBMARINE HARD TANKS	Not Applicable to Commercial Surface Ship Construction				N/A
126	SUBMARINE SOFT TANKS	Not Applicable to Commercial Surface Ship Construction				N/A

130	***HULL DECKS***	**Part 3-2-3:** All decks are covered by the Section called Decks in the rules the scantlings vary according to location and purpose but the variables usually include: LBP & spacing of deck beams.	**Part 3-1.8:** Supporting members have a section modulus requirement calculated from stiff spacing and frame spacing, pressure, corrosion factor, allowable stress.	**Part 3,5,2 & 3,6,2; Part 4,(1,4 & 2,3 & 6,4 & 7,4 & 8,4 & 12,3):** Rules change slightly for Strength, Second, and following decks. Most Scantlings are affected by: stiffener spacings, aspect ratio , material, as built(designed) section modulus, LBP, head,	**Pt C, Ch 17:** Plate Thickness: spacing of longitudinal beams, LBP, deck load.	LR has special rules for different types of ships as well as for the forward and aft portions of the ship.
131	MAIN DECK		**Part 3-1.8 C100:** Strength Deck variables are: aspect ratio, stiff. Spacing, pressure, allowable stress, & corrosion addition.	**Part 3,5,2 & 3,6,2; Part 4,(1,4 & 2,3 & 6,4 & 7,4 & 8,4 & 12,3):** Strength Deck		
132	2ND DECK			**Part 3,5,2 & 3,6,2; Part 4,(1,4 & 2,3 & 6,4 & 7,4 & 8,4 & 12,3):** Second Deck		
133	3RD DECK		**Part 3-1.8 C200:** Other deck thickness' are determined by LBP and a material factor with a corrosion addition.	**Part 3,5,2 & 3,6,2; Part 4,(1,4 & 2,3 & 6,4 & 7,4 & 8,4 & 12,3):** Third or Platform Decks.		
134	4TH DECK					
135	5TH DECK					
136	01 HULL DECK (FORECASTLE AND POOP DECKS)					
137	02 HULL DECK					
138	03 HULL DECK					
139	04 HULL DECK AND HULL DECKS ABOVE					
140	***HULL PLATFORMS AND FLATS***	**Part 3-2-3:** All decks are covered by the Section called Decks in the rules the scantlings vary according to location and purpose but the variables usually include: LBP & spacing of deck beams.	**Part 3-1.8 C200:** Other deck thickness' are determined by LBP and a material factor with a corrosion addition.	**Part 3,5,2 & 3,6,2; Part 4,(1,4 & 2,3 & 6,4 & 7,4 & 8,4 & 12,3):** Third or Platform Decks. Same variables as SWBS 133-139.	**Pt C, Ch 17:** Plate Thickness: spacing of longitudinal beams, LBP, deck load.	LR has special rules for different types of ships as well as for the forward and aft portions of the ship.
141	1ST PLATFORM					
142	2ND PLATFORM					
143	3RD PLATFORM					
144	4TH PLATFORM					
145	5TH PLATFORM					
149	FLATS					
150	***DECK HOUSE STRUCTURE***	**Part 3-2-11:** This Chapter covers many types of enclosure, special decks as well as internal structure some variables needed are: Cb, stiff. Spacing, tween deck height, design head, LBP, vertical distance from summer load line to the midpoint of the span,	**Part 3-1.10:** Scantlings affect plate and stiffeners the required variables are: aspect ratio, stiff. Spacing, pressure, allowable stress, frame spacing.	**Part 3,8,1-4:** This section covers forecastles as well as other structure and includes rules for bulkheads and decks, variables include the following: LBP, material type, Stiffening arrangement and type, Cb, Beam, Draft.	**Pt C, Ch 18,19:** Plate thickness and stiffener section modulus requirement as follows: LBP, Cb, Location of bulkhead, stiffener spacing, tween deck height.	
151	DECKHOUSE - 1ST LEVEL 01 LEVEL					
152	1ST DECKHOUSE LEVEL 02 LEVEL					
153	2ND DECKHOUSE LEVEL 03 LEVEL					
154	3RD DECKHOUSE LEVEL 04 LEVEL					
155	4TH DECKHOUSE LEVEL 05 LEVEL					
156	5TH DECKHOUSE LEVEL 06 LEVEL					
157	6TH DECKHOUSE LEVEL					
158	7TH DECKHOUSE LEVEL					
159	8TH DECKHOUSE LEVEL					

160	***SPECIAL STRUCTURES***	Part 3-2-(12-14)	Part 3-1.(15,16)	Part 3,9	**Part C, Ch 20-27:** These Chapters deal with special equipment or structures.	No Significant Difference Identified
161	STRUCTURAL CASTINGS & FORGINGS	None Found	None Found	None Found	None Found	No Significant Difference
162	STACKS	None Found	None Found	None Found	**None Found**	No Significant Difference
163	SEA CHESTS	Part 3-2-16	Part 3-1.11 K	Part 3,11,8	**Pt C, Ch 16.7.2:**	No Significant Difference Identified
164	BALLISTIC PLATING	Not Applicable to Commercial Surface Ship Construction				N/A
165	SONAR DOMES	N/A	N/A	N/A	**N/A**	N/A
166	SPONSORS	None Found	None Found	None Found	**None Found**	No Significant Difference
167	HULL STRUCTURAL CLOSURES	None Found	Part 3-1.11	Part 3,11	**None Found**	No Closure Requirements found for ABS.
168	DECKHOUSE STRUCTURAL CLOSURES	None Found	None Found	None Found	**None Found**	No Significant Difference
169	SPECIAL PURPOSE CLOSURES	None Found	None Found	None Found	**None Found**	No Significant Difference
170	***MASTS, KINGPOSTS, AND SERVICE PLATFORMS***	None Found	Part 3-3.4	None Found	**Pt C, Ch 26:**	DNV has additional rules for masts and stacks.
171	MASTS TOWERS TETRAPODS	None Found	Part 3-3.4	None Found	**Pt C, Ch 26:**	DNV has additional rules for masts and stacks.
172	KINGPOSTS AND SUPPORT FRAMES	Part 3-2-(5-6)	Part 3-3	None Found	**Pt C, Ch 26:**	No rules found in LR.
179	SERVICE PLATFORMS	Part 3-2-11	Part 3-1.10	Part 3,8,1-4	**None Found**	No Significant Difference Identified
180	***FOUNDATIONS***	Part 3-2-12/3	Part 3-1.8 E500	Part 3,7,6	**Pt C, Ch 21:**	Foundations requirements for ABS only included engine mounts.
181	HULL STRUCTURE FOUNDATIONS	None Found	Part 3-1.8 E500	None Found	**None Found**	DNV had additional rules for structure foundations.
182	PROPULSION PLANT FOUNDATIONS	Part 3-2-12/3	Part 3-1.8 E500	Part 3,7,6	**Pt C, Ch 21:**	No Significant Difference Identified
183	ELECTRIC PLANT FOUNDATIONS	Part 3-2-12/3	Part 3-1.8 E500	Part 3,7,6.5	**Pt C, Ch 21.5:**	No Significant Difference Identified
184	COMMAND & SURVEILLANCE FOUNDATIONS	None Found	Part 3-1.8 E500	None Found	**None Found**	DNV had requirements for Electronic Foundations
185	AUXILIARY SYSTEMS FOUNDATIONS	None Found	Part 3-1.8 E500	Part 3,7,6.5	**Pt C, Ch 21.5:**	No Auxiliary System foundation requirements found for ABS.
186	OUTFIT & FURNISHINGS FOUNDATIONS	None Found	Part 3-1.8 E500	None Found	**None Found**	DNV has requirements specific to Outfitting.
187	ARMAMENT FOUNDATIONS	Not Applicable to Commercial Surface Ship Construction				N/A
190	***SPECIAL PURPOSE SYSTEMS***	Part 3-2-(13,14,17)	Part 3-1.(15,16)	Part 3,9&14	**Pt C, Ch 27-:**	No Significant Difference Identified
191	BALLAST FIXED LEAD	None Found	None Found	None Found	**None Found**	No Significant Difference
192	COMPARTMENT TESTING	None Found	Part 3-1.9 A500	Part 3,1,8.3	**None Found**	No compartment testing found in ABS rules.
195	ERECTION OF SUB SECTIONS (PROGRESS REPORT ONLY)	None Found	None Found	None Found	**None Found**	No Significant Difference
196	WELDS & MILL TOLERANCE	Part 2-4 & Part 3-2-19	Part 2.3	Part 3,10	**Pt C, Ch 1.2:**	No Significant Difference Identified
198	FREE FLOODING LIQUIDS	None Found	None Found	None Found	**None Found**	No Significant Difference
199	HULL REPAIR PARTS AND SPECIAL TOOLS	None Found	None Found	None Found	**None Found**	No Significant Difference

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference / Comments
200	***PROPULSION PLANT, GENERAL***	**Part 4:** Vessel Systems and Machinery (main class)	**Part 4, Chapter 2:** Propulsion and Auxiliary Machinery	**Part 5:** Main and Auxiliary Machinery	**Part D:** Machinery Installations	General Propulsion Plant Sections (for reference only)
200	***PROPULSION PLANT, GENERAL: QUALITY ASSURANCE***	Requires component manufactures to be ISO 9000-series compliant	Requires component manufactures to be ISO 9000-series compliant	LR does not specifically indicate ISO compliance. Does require an acceptable quality assurance program/procedure be in place for manufactured components	No specific listed quality assurance organization listed. QA is met through society approval of acceptable manufacturing procedures/process	
201	GENERAL ARRANGEMENT - PROPULSION DRAWINGS	Required drawings/documentation is described for each section/topic in the rulebooks				Societies list applicable documentation, including necessary drawings, for each main section.
202	MACHINERY PLANT CENTRAL CONTROL SYSTEM	**Part 4, Chapter 9:** Remote propulsion control and automation (general, propulsion control, notations, installation, computerized, equipment) For special notation vessels, not main class	**Part 4 Chapter 5:** Instrumentation and Automation (general requirements, design principles, system design, computer based systems, component design and installation, user interface)	**Part 6 Chapter 1:** Control engineering systems (general requirements, essential features, control, special notations, trials)	**Pt D, Ch 18:** Automatic and remote control (general, system design, propulsion control, boiler control, gen sets control, auxiliary machinery control, tests)	ABS and LR have additional requirements for Automatic Shutdown. The majority of these rules are designated for special notations for centralized control, remote control, or automation of machinery. The main components of these rules are the same form society to society, no significant differences,
210	***ENERGY GENERATING SYSTEM (NUCLEAR)***	NO APPLICABLE RULES / GUIDANCES IN THE SOCIETY RULES				
212	NUCLEAR SYSTEM GENERATOR	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
213	REACTORS	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
214	REACTOR COOLANT SYSTEM	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
215	REACTOR COOLANT SERVICE SYSTEM	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
216	REACTOR PLANT AUXILIARY SYSTEMS	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
217	NUCLEAR POWER CONTROL AND INSTRUMENTATION	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
218	RADIATION SHIELDING (PRIMARY)	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
219	RADIATION SHIELDING (SECONDARY)	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
220	***ENERGY GENERATING SYSTEM (NON-NUCLEAR)***	**Part 4:** Vessel Systems and Machinery	**Part 4:** Machinery and Systems - Main Class	**Part 5:** Main and Auxiliary Machinery	**Part D:** Machinery Installations	
221	PROPULSION BOILERS	**Pt 4, Ch 4:** Boilers, pressure vessels, and fired equipment (general, materials, design, fabrication, boiler appurtenances, boiler control, fired thermal heaters, incinerators, pressure vessels and heat exchanger appurtenances, installation)	**Pt 4, Ch 3:** Boilers, pressure vessels, thermal-oil installations and incinerators (general requirements, materials, arrangement, general design requirements, particular boiler design requirements, mountings and fittings, instrumentation and automation, manufacture, tests)	**Pt 5, Ch 10:** Steam raising plant and associated pressure vessels (general, shells and drums, ends, internal pressure, standpipes and branches,. Boiler tubes, headers, plates, furnaces, construction, mountings, tests)	**Pt D, Ch 9:** Boilers Etc. and Incinerators (general, materials, design requirements, allowable stress, required dimensions, manholes and openings, tubes, joints, fittings, tests, construction, incinerators)	In general, boilers are bought from outside sources, and have little impact on a ship designer. Conforming to the rules are issues to the boiler manufacturer. General Boiler Sections, LR's layout is much different that the others. LR addressed this section by component, rather by general requirements like the others. No significant differences in the rules, much of the analysis is general engineering mechanics and fluids-based, leading to close similarities in calculation based topics. Areas where differences occur are in items such as corrosion allowance.
222	GAS GENERATORS	No applicable rule	No applicable rule	No applicable rule	No applicable rule	Societies do not have specific rule for Gas Generators
223	MAIN PROPULSION BATTERIES	For all battery rules, see SWBS 313				All batteries related to ships are covered in SWBS 313
224	MAIN PROPULSION FUEL CELLS	No applicable rule	No applicable rule	No applicable rule	No applicable rule	Societies do not have specific rules for Fuel Cells
230	***PROPULSION UNITS***	**Part 4:** Vessel Systems and Machinery	**Part 4:** Machinery and Systems - Main Class	**Part 5:** Main and Auxiliary Machinery	**Part D:** Machinery Installations	
231	PROPULSION STEAM TURBINES - OVERALL	**Pt 4, Ch 2, Sec 4:** Steam turbines	**Pt 4. Ch 2, Sec 3:** Steam Turbines	**Pt 5, Ch 3:** Steam turbines	**Pt D, Ch 3:** Steam turbines	DNV and LR are mainly concerned with testing and control of the turbine. ABS has more detailed design rules. NK has a mix of both, not as much design specifics as ABS though. In this type of application, designers and yards select type approved units, and do not engage in the design of steam turbines from scratch
231	PROPULSION STEAM TURBINES - GENERAL	**Pt 4, Ch 2, Sec 4/1:** application, definitions, deliverables	**Pt 4, Ch 2, Sec 3-A:** application, documentation	**Pt 5, Ch 3, Sec 1:** scope, plans	**Pt D, Ch 3, Sec 1:** scope, drawings and data	ABS applicable to units of 100kW or more, whereas LR is 110kW. No reference in NK and DNV

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference / Comments
231	PROPULSION STEAM TURBINES - MATERIAL	**Pt 4, Ch 2, Sec 4/3:** materials and tests	No dedicated material section or references	**Pt 5, Ch 3, Sec 2:** materials	**Pt D, Ch 3, Sec 2/1:** materials	All basically refer to the requirements from their master material rules section. LR and NK do state that cast iron is not to be used for temps above 260 and 230 deg C respectively. ABS has no reference. ABS has laid out specific material testing guidelines for specific components. LR is more specific in type of materials for specific parts than others in regard to minimum tensile strength of the material
231	PROPULSION STEAM TURBINES - DESIGN	**Pt 4, Ch 2, Sec 4/5:** design (castings, rotor shafts, blades, discs). Calcs for rotor shaft diameter, blade root area, blade elastic stresses, and blade mean tangential stress	**Pt 4, Ch 2, Sec 3-D:** design and construction (very broad and undefined except as the design is to meet general requirements for engines in environmental, operational, reliability areas	**Pt 5, Ch 3, Sec 3:** design and construction (large emphasis on welding techniques and requirements, as well as arrangement of outside components in relation to the S.T.)	**Pt D, Ch 3, Sec 2/2:** general construction (rotors, blades)	ABS has specific equations to calculate certain aspects. LR and DNV have NONE, except to state that the design is to meet all stresses and thermal considerations. NK has specific calculations the same as ABS in blade mean tangential strength (same), and blade root sectional area (same).
231	PROPULSION STEAM TURBINES - AUXILIARY DEVICES	**Pt 4, Ch 2, Sec 4/7 and Sec 4/11:** steam turbine appurtenances (overspeed protection, governors, over-pressure protection, turning gear). Installation (requirements)	**Pt 4, Ch 2, Sec 3-C and Sec 3-E:** Arrangement (general installation). Control and monitoring (same topics as ABS appurtenances). Includes detailed, itemized tables of components to be monitored	**Pt 5, Ch 3, Sec 4 and Sec 5:** Safety arrgts (overspeed protection, governors, overpressure protection, arrangement). Emergency arrgts (LO failure)	**Pt D, Ch 3, Sec 3:** Safety devices (governors, overspeed protection, steam shut-off, LO supply, exhaust steam)	All societies use same principles for protection and monitoring of steam turbines in areas listed. DNV is more slanted toward the specifics of monitoring the system than the others (list specific items and what to look for)
231	PROPULSION STEAM TURBINES - CERTIFICATION and TESTING	**Pt 4, Ch 2, Sec 4/13:** Testing, inspection, and certification.	**Pt 4, Ch 2, Sec 3-B and Sec 3-F:** Certification and testing; Testing onboard	**Pt 5, Ch 3, Sec 6:** Tests and equipment.	**Pt D, Ch 3, Sec 4:** Tests	All societies follow the same "shop" tests in regards to pressure and components.
232	PROPULSION STEAM ENGINES	No applicable rule	No applicable rule	No applicable rule	No applicable rule	
233	PROPULSION INTERNAL COMBUSTION ENGINES - OVERALL	**Pt 4, Ch 2, Sec 1:** Diesel Engines	**Pt 4, Ch 2, Sec 2:** Diesel Engines	**Pt 5, Ch 2:** Oil Engines	**Pt D, Ch 2:** Diesel Engines	Most common practice is that owner/shipyard/designer will select diesel engines from approved engine manufacturers. The ship designer will not design diesel engine specifics, hence this analysis is not as in-depth as it might otherwise be
233	PROPULSION INTERNAL COMBUSTION ENGINES - GENERAL	**Pt 4, Ch 2, Sec 1/1:** application, definitions, reference conditions, documentation	**Pt 4, Ch 2, Sec 2-A:** application and documentation	**Pt 5, Ch 2, Sec 1:** scope, documentation	**Pt D, Ch 2, Sec 1:** scope, documentation	ABS applicable to diesels of 100kW or more. LR for 110kW or more. NO limits stated in NK and DNV.
233	PROPULSION INTERNAL COMBUSTION ENGINES - MATERIAL	**Pt 4, Ch 2, Sec 1/3**: Materials and tests	**Pt 4, Ch 2, Sec 2-B3:** Testing and inspection (but no general material section). This is only a testing table for materials and engine parts	**Pt 5, Ch 2, Sec 2:** Materials and tests	**Pt D, Ch 2, Sec 2:** Materials, installation, ambient environment, tests	ABS has material requirements referring to ABS general material rules, and special considerations for hot-rolled steel bars. LR lists specifics for crankshaft material only. NK has tabular format of allowed materials and applicable tests. NK is most specific. DNV is most lax.
233	PROPULSION INTERNAL COMBUSTION ENGINES - CRANKSHAFT DESIGN	**Pt 4, Ch 2, Sec 1/5.9:** Crankshaft design. All calculations pertain to strength and stress/strain/moment analysis. No scantling/sizing equations	**Classification Note 41.3:** Calculation of crankshafts for diesel engines. Methods for calculating safety against fatigue failure. Mainly all stress/strain calcs and methods	**Pt 5, Ch 2, Sec 3:** Design (crankshafts). Only calculates stresses, shears, moments, and strengths for specific aspects...no plug and chug equations for scantlings	**Pt D, Ch 2, Sec 3:** Crankshafts (crankpin diameter - 15 variables; built-up crankshaft crank web thickness - 9 variables; coupling bolt diameter - 4 variables). **Annex D2.3.1** - Crankshaft stress calcs	This is mainly NOT a ship designer aspect. ABS, DNV, and LR are all focused on analyzing the strength of the component. NK includes scantling equations, and strength analysis in an annex.
233	PROPULSION INTERNAL COMBUSTION ENGINES - AUXILIARY DEVICES	**Pt 4, Ch 2, Sec 1/7:** Engine appurtenances (valves, governors, overspeed protection, monitoring, monitoring)	**Pt 4, Ch 2, Sec 2-D and Sec 2-E:** valves, safety, governors, monitoring, control, overspeed protection)	**Pt 5, Ch 2, Sec 5 and Sec 6:** Safety Arrgt and Crankcase Safety (relief valves, governors, overspeed protection)	**Pt D, Ch 2, Sec 4:** Safety devices (governors, overspeed protection, relief valves)	All societies have the same requirements, standards for diesel engine monitoring and safety considerations.
233	PROPULSION INTERNAL COMBUSTION ENGINES - CERTIFICATION and TESTING	**Pt 4, Ch 2, Sec 1/13:** Testing, inspection and certification of diesels (type approval, ship tests, certification) **Pt 4, Ch 2, Sec 1/15:** Shipboard trials (static tests, operational tests)	**Pt 4, Ch 2, Sec 2-B:** Certification and Testing (type-testing, static tests, etc) **Pt 4, Ch 2, Sec 2-F:** Onboard Testing (operational trials)	**Pt 5, Ch 2, Sec 9:** Component testing and type testing (static tests, type approval) **Pt 5, Ch 1, Sec 5/2:** Sea trials (operational trials for diesels)	**Pt D, Ch 2, Sec 6:** Tests (shop tests (hydrostatic pressure tests)) **Pt D2, Sec 6 (guidance):** shop tests for operations	Not necessarily a "design" aspect, but a consideration when selecting your engine. Requires proper machinery configuration and integration in parts. All operational trials testing and hydrostatics hydraulic pressure testing are virtually identical

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference / Comments
234	PROPULSION GAS TURBINES - OVERALL	**Pt 4, Ch 2, Sec 3:** Gas Turbines	**Pt 4, Ch 2, Sec 4:** Gas Turbines	**Pt 5, Ch 4:** Gas Turbines	**Pt D, Ch 4:** Gas Turbines	Most common practice is that owner/shipyard/designer will select GTs from approved engine manufacturers. The ship designer will not design gas turbine specifics, hence this analysis is not as in-depth as it might otherwise be.
234	PROPULSION GAS TURBINES - GENERAL	**Pt 4, Ch 2, Sec 3/1:** application, definitions, documentation	**Pt 4, Ch 2, Sec 4-A:** application, documentation, standards	**Pt 5, Ch 4, Sec 1:** plans, scope	**Pr D, Ch 2, Sec 1:** scope, documentation	ABS is for 100+kW, LR is 110+kW. No requirements as such in NK and DNV. Just stated as Gas Turbines for propulsion, aux power, or drive generators
234	PROPULSION GAS TURBINES - MATERIALS	**Pt 4, Ch 2, Sec 3/3:** materials and tests	No dedicated material section or references	**Pt 5, Ch 4, Sec 2:** materials	**Pt D, Ch 4, Sec 2:** materials, construction, and strength	
234	PROPULSION GAS TURBINES - DESIGN	**Pt 4, Ch 2, Sec 3/5:** design (rotors, blades) All subsystems are referred to general systems, (FO, LO sys, etc)	**Pt 4, Ch 2, Sec 4-D:** design and construction (piping, LO, FO, starting systems) Refers to general reqts for main rules.	**Pt 5, Ch 4, Sec 3:** design and construction (general, basis, welding, vibration, exhaust)	no "design" section or "rules" in NK. Requires that the design meet the demands of the operating environment and w/o excessive vibrations and stresses	ABS includes durability limits between overhauls. All societies leave design to hands of designers. Designs must be made to withstand applicable stresses and environment expected to be encountered by the part/system
234	PROPULSION GAS TURBINES - ASSOCIATED EQUIPMENT	**Pt 4, Ch 2, Sec 3/7:** GT appurtenances (safety devices, overspeed protection, governors, alarms, monitoring, controls)	**Pt 4, Ch 2, Sec 4-E:** control and monitoring (overspeed protection, governors, alarms, monitoring, controls)	**Pt 5, Ch 4, Sec 4:** safety arrgts (overspeed protection, governors, controls)	**Pt D, Ch 4, Sec 3:** safety devices (governors, overspeed protection, controls, alarms, monitoring)	All societies describe the same controls and safety devices. ABS and DNV are specific in the systems to be monitored and controlled. In the end, all lead to same results for design of the systems
234	PROPULSION GAS TURBINES - TESTING and CERTIFICATION	**Pt 4, Ch 2, Sec 3/13:** testing, inspection and certification (shop tests, type approval, pressure tests, shipboard trials)	**Pt 4, Ch 2, Sec 4-F:** testing onboard (proper operational requirements met, vibration measurement) **Pt 4, Ch 2, Sec 4-B:** certification and testing (type testing, list of component testing, manufacturing standards, start test, mechanical run test, performance test, certification test: these tests are referenced to applicable commercial standards, e.g. ISO)	**Pt 5, Ch 4, Sec 6:** Tests (balancing, pressure, overspeed, shop) Limited information on testing and certification in LR	**Pt D, Ch 4, Sec 5:** tests (shop/pressure test information only) Nothing on certification. Heavy on requirements for turbine rotors over other societies	Individual trial tests/requirements composed from builder and society to an agreeable format. But all state basic operational requirements must be shown during seatrials. DNV has extensive testing/certification procedure, whereas other are more lax.
235	ELECTRIC PROPULSION	**Pt 4, Ch 8, Sec 5/5:** Electric Propulsion Systems (application, plans and data, power supply systems, circuit protection, earth leakage protection, propulsion control, instrumentation, installation and arrangements, equipment requirements, trials)	**Pt 4, Ch 4, Sec 11:** Electric Propulsion (general requirements, design principles, electrical system design, control system design, tests)	**Pt 6, Ch 2, Sec 15:** Electric Propulsion (general, power requirements, propulsion control, system protection, instruments)	**Pt H, Ch 5:** Electric Propulsion Plants (general, electrical equipment and cables, propulsion motors, arrangement, supply circuits, measuring equipment)	ABS deals with installation and arrangements, whereas DNV is more design bases. LR has the least information on this topic, leaving the designer/engineer's best practice to dictate the majority of the design.
236	SELF-CONTAINED PROPULSION SYSTEMS	No applicable rule	No applicable rule	No applicable rule	No applicable rule	
237	AUXILIARY PROPULSION DEVICES	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
238	SECONDARY PROPULSION (SUBMARINES)	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
239	EMERGENCY PROPULSION (SUBMARINES)	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
240	***TRANSMISSION AND PROPULSOR SYSTEMS***	**Part 4:** Vessel Systems and Machinery	**Part 4:** Machinery and Systems - Main Class	**Part 5:** Main and Auxiliary Machinery	**Part D:** Machinery Installations	
241	PROPULSION REDUCTION GEAR	**Pt 4, Ch 3, Sec 1:** Gears (general, materials, design, piping, testing, inspection, certification)	**Pt 4, Ch 2, Sec 5:** Gear Transmissions (general, certification and testing, design and construction, arrangement, monitoring, assembly and testing) **Pt 5, Ch 1, Sec 3 and Sec 4:** Ships for navigation in ice requirements	**Pt 5, Ch 5:** Gearing (plans, particulars, materials, design, construction, tests)	**Pt D, Ch 5:** Power Transmission Systems (general, materials and construction, strength, gear shafts, tests)	Most common practice is that owner/shipyard/designer will select reduction gears from approved gear/engine manufacturers. The ship designer will not design reduction gear specifics, hence this analysis is not as in-depth as it might otherwise be. Design is driven by prime mover output compared to propulsor curves and operational requirements from the ship designer viewpoint

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference / Comments
242	PROPULSION CLUTCHES AND COUPLINGS	**Pt 4, Ch 3, Sec 2/5.19:** Couplings and coupling bolts (propulsion shafting)	**Pt 4, Ch 2, Sec 6-D17:** Clutches (general and friction capacities)	**Pt 5, Ch 6, Sec 7:** Couplings **Pt 5, Ch 6, Sec 8:** Coupling Bolts (rpm, # bolts, power, strength, pitch circle diameter of bolts)	**Pt D, Ch 2, Sec 3/3:** Shaft couplings and coupling bolts (diesel crankshafts) **Pt D, Ch 5, Sec 4/3:** couplings and coupling bolts **Pt D, Ch 6, Sec 2/12:** Shaft couplings and coupling bolts (	ABS refers to ABS Type Approved Equipment or Inspection while DNV and LR have more specific rules. Differences are minor, and have minimal impact on design efforts. The basis of the rules have no significant difference
243	PROPULSION SHAFTING	**Part 4, Chapter 3, Section 2:** Propulsion Shafting	**Part 4, Chapter 2, Section 6:** Shafting and Vibrations	**Part 5 Chapter 6:** Main Propulsion Shafting	**Part D, Chapter 6:** Shaftings	General Shafting Sections (for reference only)
243	PROPULSION SHAFTING - PROPELLER SHAFTS	**Pt 4, Ch 3, Sec 2/5:** Propulsion shafting design and construction	**Pt 4, Ch 2, Sec 6-D4:** Propeller shafts	**Pt 5, Ch 6, Sec 3/5:** Screwshafts and tube shafts	**Pt D, Ch 6, Sec 2/4:** Propeller shafts and stern tube shafts	No significant difference. All identical inputs and formulas for solid and hollow propeller shafts
243	PROPULSION SHAFTING - INTERMEDIATE SHAFTS	**Pt 4, Ch 3, Sec 2/5:** Propulsion shafting design and construction	**Pt 4, Ch 2, Sec 6-D5:** Intermediate shafts	**Pt 5, Ch 6, Sec 3/1:** Intermediate shafts	**Pt D, Ch 6, Sec 2/2:** Intermediate shafts	ABS has additional factors for specific design features of line shafts that the others do not. But the "base" designs are equivalent.
244	PROPULSION SHAFT BEARINGS	**Pt 4, Ch 3, Sec 2/5.15:** Tail shaft bearings (water, oil, and grease lubricated; synthetic and cast materials)	**Pt 4, Ch 2, Sec 6-D8:** Stern tube and bearings	**Pt 5, Ch 6, Sec 3/12:** Sternbushes (bearing lengths (for different configurations) and arrangement	**Pt D. Ch 6, Sec 2/10:** Stern tube bearings and shaft bracket bearings	No Significant Difference Identified. NK does mention more reference to bearing length in relation to actual shaft diameters, not rule required diameters. All will result in same answer.
245	PROPULSORS - OVERALL	**Pt 4, Ch 3, Sec 3:** Propellers (this propeller section applicable to PROPULSION propellers ONLY)	**Pt 4, Ch 2, Sec 7:** Propellers (ALL propellers covered in this section)	**Pt 5, Ch 7:** Propellers (no reference to scope)	**Pt D, Ch 7:** Propellers (applicable to screw propellers)	Differences only in the applicable scope for this particular major section in the rules. ABS Rules for maneuvering and positioning propellers are in 4-3-5.
245	PROPULSORS - GENERAL	**Pt 4, Ch 3, Sec 3/1:** General (application, definitions, documentation)	**Pt 4, Ch 2, Sec 7-A:** General (application, documentation)	**Pt 5, Ch 7, Sec 1:** Plans and particulars (documentation)	**Pt D, Ch 7, Sec 1/1:** Scope **Pt D, Ch 7, Sec 1/2:** Documentation	All societies have generally the same requirements for submitted documentation
245	PROPULSORS - MATERIALS	**Pt 4, Ch 3, Sec 3/3:** Materials (tabular listing of major propeller materials)	**Pt 4, Ch 2, Sec 7-B1: Certification and Testing - General (refers to DNV general rules for materials and welding, Pt 2, Ch 2, Sec 10-C)**	**Pt 5, Ch 7, Sec 2:** Materials (tabular listing of major propeller materials)	**Pt D, Ch 7, Sec 1/3:** Materials (refers to general NK Materials Section **Pt K, Ch 7, Sec 2**)	No significant difference in materials for propeller castings
245	PROPULSORS - DESIGN	**Pt 4, Ch 3, Sec 3/5:** Design (Blade thickness for: FPP, CPP, Highly-skewed. CPP stud bolt area)	**Pt 4, Ch 2, Sec 7-D:** Scantlings (Blade thickness, blade root radius)	**Pt 5, Ch 7, Sec 3:** Design (blade thickness, conventional and highly-skewed)	**Pt D, Ch 7, Sec 2:** Construction and Strength (blade thickness for conventional CPP, and FPP) **Guidences D7, Sec 2:** Blade thickness for highly-skewed propellers)	The particulars of the individual propeller will be carried out by the propeller manufacturer (usually NOT the shipyard). The designer will input basic characteristics to the propeller company, who will undertake calculation like those presented in the rules. However, in these rules, ABS has the most variables (15), same as NK. DNV and LR have 12, and 11 respectively. Although DNV has total 24 inputs with factors and coefficients, the most
245	PROPULSORS - INSTALLATION	**Pt 4, Ch 3, Sec 3/5.15:** Propeller fitting (keyed, and keyless). Key less attachment require extensive calcs **Pt 4, Ch 3, Sec 3/9:** final installation arrangements and checks	**Pt 4, Ch 2, Sec 7-F1:** Fitting (verification by surveyor) **Pt 4, Ch 2, Sec 6-D9**: Fitting of propeller to shaft (cone-mounted, keyless, key mounted)	**Pt 5, Ch 7, Sec 4:** Fitting of propellers (propeller boss, final fitting of keyless props) **Pt 5, Ch 7, Sec 3/2:** Keyless propellers (pull-up length)	**Pt D, Ch 7, Sec 3:** Force fitting of propellers (keyed and keyless) Pull-up length calculations	All societies, except DNV, include detailed calculations for pull-up length for keyless fitting of propellers. DNV provides guidelines and some final requirements for fitting, but no detailed formulas for it.
245	PROPULSORS - TESTS AND TRIALS	**Pt 4, Ch 3, Sec 3/9:** operational and performance trials/verification	**Pt 4, Ch 2, Sec 7-F3:** Sea Trial (operational trials)	**Pt 5, Ch 7, Sec 4/2:** Shop tests of keyless propellers (proper verification of pull-up length and axial position for boss)	**Pt D, Ch 7, Sec 4:** Tests (see guidences) **Guidences D7, Sec 4:** Tests (static balancing shop test, confirmation of pull-up length)	All societies check/test for propeller fitting verification. LR and NK do not list any specific operational/performance testing in these applicable sections
246	PROPULSOR SHROUDS AND DUCTS	No applicable rule	**Pt 3, Ch 3, Sec 2-H:** Propeller nozzles (plating scantlings, welding, support, stiffness)	**Pt 3, Ch 13, Sec 3:** Fixed and steering nozzles (shroud scantlings and associated considerations and scantlings)	No applicable rule	ABS and NK have no dedicated rules/scantlings for propeller shrouds, ducts, or nozzles. LR and DNV have empirical equations for calculating such structural members related to shrouds and ducts.
247	WATER JET PROPULSORS	**High Speed Craft, Part 4, Section 7/36:** Waterjets (very limited scope, only specifics for stress calcs for Waterjet components) Also speaks of impeller bearings	**High Speed and Light Craft, Part 4, Chapter 2, Section 7:** Water Jet Units (includes IMO HSC regulations). Covers general reqts, certification and testing, arrangement, layout, design, construction, control and monitoring, assembly, testing	**Special Service Craft, Volume 7. Part 12, Chapter 2:** Water Jet Systems (includes IMO HSC regulations). Also includes, general reqts, materials, design, construction, piping, control, electrical	**Rules for High Speed Craft, Part 9, Chapter 5/3:** Waterjet propulsion Systems (no specific rules) **RHSC Gudiances Pt 9, Ch 5:** Waterjets (shaft diameter, shaft coupling bolts, stresses, vibration, strength considerations for waterjets) A lot of reference to general rules for waterjet components	ABS rules are barren compared to DNV and LR. DNV and LR have COMPLETE design criteria and section for waterjets and waterjet systems. NK has more than ABS, but is limited as well.

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference / Comments
248	LIFT SYSTEM FANS AND DUCTING	**High Speed Craft, Part 4, Section 7/38:** Propulsion and Lift Devices for Air Cushion Vehicles (includes only reference to design to applicable levels and viable, practical arrangement)	No applicable rule	**Air Cushion Vehicles:** Includes complete rules and guidances for the classification of air cushion vehicles	No applicable rule	DNV and NK lack rules for Lifting devices. ABS is very limited in its guidance for this SWBS. States that everything jus needs to be practical and within stress/strength levels that will be experienced by system, but no concrete rules.
250	***PROPULSION SUPPORT SYS. (EXCEPT FUEL AND LUBE OIL)***	**Part 4:** Vessel Systems and Machinery	**Part 4:** Machinery and Systems - Main Class	**Part 5:** Main and Auxiliary Machinery	**Pt D:** Machinery Installations	
251	COMBUSTION AIR SYSTEM - TURBOCHARGERS	**Pt 4, Ch 2, Sec 2:** Turbochargers (application, definitions, documentation, materials, design, installation, testing, inspection, certification)	**Pt 4, Ch 2, Sec 9:** Turbochargers (application, documentation, certification, testing, arrangement, design, monitoring)	**Pt 5, Ch 3, Sec 10:** Turbo-chargers (documentation, testing)	**Pt D, Ch 2, Sec 5:** Exhaust driven turboblowers (general reqts, no specifics)	Common practice dictates turbochargers being designed and provided from source vendors and engine manufacturers, not a "ship" designer's responsibility. However, the ABS rules are applicable to turbochargers on engines over 100kW, whereas DNV is 1000+kW. ABS is heavy on type testing and certification. All have same operational testing reqts. ABS design will cover all societies. LR is most open ended. NK is bare bones w/ no vital specifics
252	PROPULSION CONTROL SYSTEM	**Pt 4, Ch 9:** Remote propulsion control and automation	**Pt 4, Ch 2, Sec 1-E:** Control and monitoring (incl. machinery and propulsion general reqts) **Pt 4, Ch 5:** Instrumentation and automation (includes mainly specifically equipment design, but also ergonomics or configuration)	**Pt 5, Ch 18:** Integrated Propulsion Systems	**Pt D, Ch 18:** Automatic and remote control (propulsion)	No Significant Difference Identified
253	MAIN STEAM PIPING SYSTEM	**Pt 4, Ch 6, Sec 6/3:** Steam piping system	**Pt 4, Ch 1, Sec 5-G:** Steam Systems (piping, valves, supply)	**Pt 5, Ch 14, Sec 5:** Steam piping systems	**Pt D, Ch 13, Sec 14:** Steam piping systems and condensate systems	ABS Rules are specific than DNV and LR. (MORE REVIEW OF GENERAL PIPING FROM THE SOCIETIES IS NECESSARY TO COMPLETE THIS)
253	MAIN STEAM PIPING SYSTEM - GENERAL	See SWBS 505 for GENERAL PIPING REQUIREMENTS for BASIC REQUIREMENTS NOT COVERED IN ABOVE SWBS				All societies refer and/or expect the basic general piping requirements to be followed and conformed to, with any additional requirements for steam piping added on top or superceding general rules.
254	CONDENSERS AND AIR EJECTORS	No applicable rule	No applicable rule	**Pt 5, Ch 3, Sec 3/7:** Steam supply and water system (steam turbines)	No applicable rule	Lloyds discusses this issue in terms of the connection of these components...not the design
255	FEED AND CONDENSATE SYSTEM	**Pt 4, Ch 6, Sec 6/5:** Boiler feed water and condensate systems (general, system design, boilers, system components, monitoring, tests and trials)	**Pt 4, Ch 1, Sec 5-F:** Feed water and condensate systems (pumps, piping, heating, tanks, evaporators)	**Pt 5, Ch 14, Sec 6:** Boiler feed water and condensate systems (piping, pumps, harbor pumps, condensate pumps, valves and cocks, reserve feed water)	**Pt D, Ch 13, Sec 14:** Steam piping systems and condensate systems **Pt D, Ch 13, Sec 15:** Feed water systems for boilers **Pt D, Ch 9, Sec 9/5:** Feed water system (construction & fittings for boilers)	No Significant Difference Identified
256	CIRCULATING & COOLING SEAWATER SYSTEMS	**Pt 4, Ch 6, Sec 5/7:** Combustion Engines - Cooling System, Piping (general, system components (pumps, coolers, fittings and joints), sea chests, for propulsion and auxiliary engines (cooling water pumps, strainers, circulation, monitoring), tests) **Pt 4, Ch 6, Sec 6/11:** SW circulation and cooling systems (steam plants, general, condenser, LO cooling, components, monitoring, tests and trials)	**Pt 4, Ch 1, Sec 5-B:** Cooling Systems (all machinery, general, water supply, sea inlets)	**Pt 5, Ch 14, Sec 7:** Engine cooling water systems (main supply, standby supply, pumps, relief valves, sea inlets, strainers)	**Pt D, Ch 2, Sec 5/6:** Cooling arrgts (diesels) **Pt D, Ch 13, Sec 12:** Cooling Systems (main propulsion machinery, general, SW suction)	ABS has specific rules for Steam Plant cooling and Internal Combustion Cooling; DNV has rules for any type of cooling system; LR has rules for any engine cooling system.
258	HIGH PRESSURE STEAM DRAIN SYSTEM					
259	UPTAKES (INNER CASING)	**Pt 4, Ch 6, Sec 5/11:** Exhaust gas piping (diesel, GT, steam plants) **Pt 4, Ch 6, Sec 6/13:** Exhaust gas piping for steam plant (ref to above)	**Pt 4 Ch 2, Sec 2-C3:** Exhaust Pipes (diesels) **Pt 4, Ch 2, Sec 4-C:** General arrgt (gas turbines) includes exhaust	**Pt 5, Ch 2, Sec 7/3:** Exhaust systems (oil engines) **Pt 5, Ch 10, Sec 11/9:** Uptakes of vertical boilers (boilers / steam plants)	**Pt D, Ch 2, Sec 5/2:** Exhaust gas arrgts (diesels) **Pt D, Ch 13, Sec 16:** Exhaust gas piping arrgt (all) **Pt D, Ch 4, Sec 4/2:** Exhaust gas arrgt (gas turbine) **Pt D, Ch 9, Sec 13/3:** Construction and fittings (boilers)	ABS has requirements for Temperature Alarms in Unmanned Engine Spaces; DNV has no special Requirements; LR has some special Insulation Requirements

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference / Comments
260	***PROPULSION SUPPORT SYSTEMS (FUEL AND LUBE OIL)***	**Part 4:** Vessel Systems and Machinery	**Part 4:** Machinery and Systems - Main Class	**Part 5:** Main and Auxiliary Machinery	**Pt D:** Machinery Installations	
261	FUEL OIL SERVICE SYSTEM	**Pt 4, Ch 6, Sec 4/13:** FO Storage and Transfer system **Pt 4, Ch 6, Sec 5/3:** FO Systems (combustion engines) **Pt 4, Ch 6, Sec 6/7:** FO Systems (steam turbines)	**Pt 4, Ch 1, Sec 5-D:** FO Systems General (tanks, piping, valves, controls, pumps, etc) **Pt 6, Ch1, Sec 6:** FO Systems for vessels w/ additional pollution prevention measures (arrgt, sundry) **Pt 4, Ch 2, Sec 2-D8**: Fuel System (diesels) cams and valve train (cyl bore >250mm)	**Pt 5, Ch 2, Sec 7:** Oil fuel systems (diesels) piping **Pt 5, Ch 14 Sec 2:** Oil fuel - Gen. Requirements **Pt 5, Ch 14, Sec 3:** Oil fuel burning arrgts **Pt 5, Ch 15, Sec 4:** Oil fuel pumps, pipes, fittings, tanks, etc.	**Pt D, Ch 2, Sec 5/4:** FO Arrangement (diesels) **Pt D, Ch 4, Sec 4/5:** FO Arrgt (gas turbines) **PT D, Ch 13, Sec 9:** FO Systems General(all)	All societies discuss the same topics and cover the same areas. All societies reach the same conclusions regarding these topics.
262	MAIN PROPULSION LUBE OIL	ALL LUBE OIL MATTERS COVERED IN SWBS 264 FOR ALL APPLICABLE SYSTEMS				
263	SHAFT LUBE OIL SYSTEM (SUBMARINES)	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION				
264	LUBE OIL FILL TRANSFER & PURIFICATION	**Pt 4, Ch 6, Sec 4/15:** LO Storage and Transfer system (storage and transfer systems, fire minimization) **Pt 4, Ch 6, Sec 5/5:** LO Systems (combustion engines) - machinery protection, supply, and redundancy **Pt 4, Ch 6, Sec 6/9:** LO Systems (steam turbines) - machinery protection, supply, and redundancy	**Pt 4, Ch 1, Sec 5-C:** LO system - General; **Pt 4, Ch 2, Sec 2-D7:** LO system for diesels; **Pt 4, Ch 2, Sec 5-D6:** Gear lubrication	**Pt 5, Ch 14, Sec 8:** Lubrication oil systems; **Pt 5, Ch 14, Sec 4:** Pumps, valves, fittings, etc	**Pt D, Ch 2, Sec 5/5:** LO Arrangement (diesels) **Pt D, Ch 4, Sec 4/6:** LO Arrgt (gas turbines) **Pt D, Ch 5, Sec 2/5:** LO Arrgt (gears) **PT D, Ch 13, Sec 10:** LO Systems (all)	All societies discuss the same topics and cover the same areas. All societies reach the same conclusions regarding these topics.
290	***SPECIAL PURPOSE SYSTEMS***					
298	PROPULSION PLANT OPERATING FLUIDS	**Pt 4, Ch 6, Sec 4/13.1:** FO General (fuel oil flash point requirements) **Pt 4, Ch 6, Sec 5/3.1:** FO Systems General (same as above listing)	**Pt 4, Ch 1, Sec 5-D1:** FO System (flash point considerations)	**Pt 5, Ch 14, Sec 2/1:** Oil Fuel General Reqts (flash point considerations)	**Pt D, Ch 1, Sec 3/3**: Limitation in the use of FO (flash point considerations)	No Significant Difference Identified
299	PROP PLANT REPAIRS & TOOL	**Pt 4, Ch 3, Sec 1: Appendix 2 -** Propulsion/Maneuvering Machinery Spare Part Guidance; **Pt 4, Ch 2, Sec 1: Appendix 2 -** Prime Movers Spare Part Guidance	**Pt 4, Ch 1, Sec 8:** Recommended Spare parts (machinery and electrical)	**Pt 5, Ch 16:** Spare Gear for Machinery Installations	**Pt D, Ch 21:** Spare Parts, Tools, and Instruments for all Machinery Installations	Spares and tools are not REQUIRED for class, but sections provide recommendations and guidance for owner. Society does however assume sufficient spares WILL BE carried aboard during operation

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
300	*ELECTRICAL PLANT, GENERAL*	**Part 4 - Chapter 8**	**Part 4 - Chapter 4**	**Part 6 - Chapter 2**	**Part H**	**Electrical rules for main class are mainly the same. All societies have special section of portions dedicated to specific types of vessels like oil carriers, chemical carriers and the like, where special rules are necessary. Many of these vessel-specific rules are regulated by the applicable IMO document.**
301	GENERAL ARRANGEMENT - ELECTRICAL DRAWINGS	**Pt 4, Ch 8, Sec 1/5:** Plans and Data (required drawings and data to be submitted to ABS - system plans, installations plans, equipment plans)	**Pt 4, Ch 4, Sec 1-C:** Documentation (plans and particulars to be submitted to DNV)	**Pt 6, Ch 2, Sec 2:** Plans (plans, documents, particulars to be submitted to LR)	**Pt H, Ch 1, Sec 1/6:** Drawings and Data (required drawings and data to be submitted to NK) **Pt H, Ch 1, Sec 6:** Drawings and Data	All drawings must be in good engineering practice and include basically the same information between all societies
302	MOTORS AND ASSOCIATED EQUIPMENT	**Pt 4, Ch 8, Sec 3/3:** Rotating Machines (application, definitions, rating, overload/over-current capacity, short circuit capability, construction, generator control, testing, certification) IEC 60034-1, IEC 60092-202, IEC 60092-301	**Pt 4, Ch 4, Sec 5:** Rotating Machines (general, mechanical part requirements, terminal connections, marking, insulating materials, temp rise, overloads, high-voltage test, testing, AC generators, DC generators, starting voltage take-up) IEC 60092-301, IEC 60034-1	**Pt 6, Ch 2, Sec 8:** Rotating Machines (general, rating, temperature rise, generator control, overloads, enclosures, DC machines, survey and testing) IEC 60092, IEC 60034 references	**Pt H, Ch 2, Sec 4:** Rotating Machines (prime movers for generators, characteristics of governors, temperature rise, temp rise modifications, overload, short-circuit scaling, overspeed, shaft currents, condensation and moisture, machine shaft, clearance, creepage in terminal boxes, DC generators, AC generators, tests)	In most cases, such machinery and components are bought from vendors from specification requirements, thus having minimal impact on the ship designer with respect to detailed design of rotating motors. For overload/over-current capability for ABS, they only list AC generators and motors and reference IEC 60034-1 for the applicable rules/standards. DNV has complete standards for this section and also references IEC 60034-1. NK has much more stringent duration for AC generators on over-current capability. LR does not list require overspeed governors like the others. DNV's is not in electrical section, but in machinery-engine sections. All are standard. Otherwise, no significant impact differences.
303	PROTECTIVE DEVICES	**Pt 4, Ch 8, Sec 2/9:** System Protection (general, short circuit, overload, device coordination, load shedding, generators, feeder cable, accumulator battery, motor circuit, transformer circuit, branch lighting)	**Pt 4, Ch 4, Sec 3-F:** Circuit Protection (general, steering gear circuit, generator circuit, feeder circuits, control circuits, motor circuits, secondary circuits from power convertors)	**Pt 6, Ch 2, Sec 6:** System Protection (general, short circuit, overload, earth faults, circuit breakers, fuses, circuit breakers w/ fuses, generators, load management, feeder circuits, motor circuit, transformer)	**Pt H, Ch 2, Sec 3:** System Protection Design (general, overload, short circuit, circuit, generator, load shedding, feeder circuit, lighting transformer, motor, lighting, control circuit, battery) **Guidance H2.3:** System Design - Protection (short circuit, generator, feeder circuits)	No significant differences from society to society. All have the same "backbone." DNV provides most specifics and detail in respect to the rules. Although they do not cover the same spectrum of topics the others speak to in these particular sections like battery protection. LR has detailed formulas to calculate the prospective fault current in the absence of precise data, the others do not, but NK does have suggestions.
304	ELECTRIC CABLES	**Pt 4, Ch 8, Sec 3/9:**Cables (compliance stds, current capacity, flame retardant, fire resistance, temp rating, armour, fibre optics, sheaths, tests, splices, junction boxes) **Pt 4, Ch 8, Sec 2/7:** Cable Sizing Requirements **Pt 4, Ch 8, Sec 4/21:** Cable Installation (general, current capacity, voltage drop, single conductor, support, deck and bhd penetrations, bending radii, protection, emergency feeders, insulation, fibre optics, splices, junction boxes, cable ends) Invokes IEC 600929 series as well as IEEE 45 for cables	**Pt 4, Ch 4, Sec 7:** Cables (general, conductors, insulation, sheaths, armor, switchboard wires, mineral-insulated, instrumentation and communication cables, control cables, fibre optic, flexible cables, approval) **Pt 4, Ch 4, Sec 3:** System Design - Choice of Cable Types (general, temperature, insulating materials, protection, parallel connection, current ratings, AC installations) IEC 60092-350 stated as the standard.	**Pt 6, Ch 2, Sec 10: Electric Cables** (general, testing, voltage rating, operating temp, construction, conductor, current rating correction, installation, protection, securing, structure penetration, installation in casings, AC current considerations, cable ends, joins, branches) Invokes appropriate IEC 60092 series standards for electric cables	**Pt H, Ch 2, Sec 9: Cables** (general, choice, coatings, flame retardancy, load, voltage drop, lighting load, current rating, installation, fire precautions, hazardous areas, earthing, supports and fixing, bhd/deck penetration, cable in pipe, cable in reefer stores, AC current, terminals, joins, branches) IEC 60092 or equivalent for cables	All societies reference IEC publications for cables and the specific cable characteristics. LR allows larger spacing for cable run supports than the other societies.

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
305	ELECTRICAL DESIGNATING AND MARKING	**Pt 4, Ch 8, Sec 3/3.11.8:** Rotating Machine Nameplates (necessary info) **Pt 4, Ch 8, Sec 3/7.3.5:** Transformer & Converters Nameplates (necessary info)	**Pt 4, Ch 4, Sec 2-G:** Markings - Design Principles (nameplates, equipment) **Pt 4, Ch 4, Sec 8-G:** Misc Equip Markings **Pt 4, Ch 4, Sec 1-D:** Signboards - General Reqts (references to other sections) **Pt 4, Ch 4, Sec 3-A203:** Max Voltages (socket outlet marking) **Pt 4, Ch 4, Sec 9-B51(4/5):** Battery labels and markings	**Pt 6, Ch 2, Sec 7/13:** Labels (circuits, associated devices, fuses, boards)	**Guidance H2.1.3.4:** Enclosure Markings (degree of protection)	ClassNK has no specific reference in their main rules regarding any markings or signboards, except for the noted section in the Guidances. All societies have different rules for specific markings and designations. Need to reference specific rules to meet class requirement. Various remarks on markings and such are made throughout many other sections of the rules on machinery and/or components that pertain to that particular section.
310	***ELECTRIC POWER GENERATION***					
311	SHIP SERVICE POWER GENERATION - MAIN POWER SOURCES, (SYSTEM DESIGN)	**Pt 4, Ch 8, Sec 2/3:** Main Source of Electrical Power (number, capacity, shaft generators, transformers, location, arrangement, main switchboard)	**Pt 4, Ch 4, Sec 3-B2:** Main Source of Electric Power and Lighting System (capacity, arrangements, reserve capacity)	**Pt 6, Ch 2, Sec 2:** Main Source of Electrical Power (general, number, rating, arrangements)	**Pt H, Ch 3, Sec 2:** Main Source of Electrical Power and Lighting Systems (capacity, arrangements, reserve capacity) **Guidance H3.2:** Main Source of Electrical Power and Lighting Systems	No significant differences. All societies either guided by or use the applicable IMO SOLAS regulations to govern this section. Applicable SOLAS reference is Ch II-1, Reg 41
311	SHIP SERVICE POWER GENERATION - ROTATING MACHINES (SYSTEM DESIGN)	**SEE SWBS 302 - MOTORS and ASSOCIATED EQUIPMENT for ALL MOTORS**				
312	EMERGENCY GENERATORS - EMERGENCY POWER SOURCES (SYSTEM DESIGN)	**Pt 4, Ch 8, Sec 5:** general, location, services, short duration voyages, power sources, transitional source, emergency switchboard, starting arrangements	**Pt 4, Ch 4, Sec 3-C:** general, services, arrangement, transitional source, emergency switchboard, inclinations, testing, starting arrangements	**Pt 6, Ch 2, Sec 3:** general, location, capacity, services, transitional source, power sources, emergency switchboard, starting arrangements (3.4), governors (3.5), radio installations (3.6)	**Pt H, Ch 3, Sec 3:** general, capacity, power sources, performance, transitional source, location, testing, starting arrangements, service specific	No significant differences. All societies either guided by or use the applicable IMO SOLAS regulations to govern this section. Applicable SOLAS reference is Ch II-1, Reg 43. ABS does state the non-emergency service uses, whereas the others do not mention using emergency power for non-essential services
313	BATTERIES & SERVICE FACILITIES - GENERAL	**Various sections/parts throughout Pt 4, Ch 8, Sec 2 and Sec 4:** (itemized below)	**Pt 4, Ch 4, Sec 3-D:** Battery Installation (charging devices, connection and protection, starting arrangements, battery trucks, references)	**Pt 6, Ch 2, Sec 11:** Batteries (general, construction, location, installation, ventilation, charging, electrical equipment)	**Pt H, Ch 2, Sec 11:** Accumulator Batteries - Design (general, construction, location, installation, ventilation, charging) **Also see the** GUIDANCES in back of book for additional information	All societies cover the same basic topics for batteries. Overall, DNV seems to have the most information/rules for this topic., and includes the battery truck charging station
313	BATTERIES & SERVICE FACILITIES - INSTALLATION	**Pt 5, Ch 8, Sec 4/5:** Installation and facilities (applicability, cell arrangement, nameplates, references)	**Pt 4, Ch 4, Sec 9-B5:** Battery Installation, Etc. (battery spaces, deck boxes, protection, coatings, materials, ventilation, cells, labels)	**Pt 6, Ch 2, Sec 11/2 and 11/4:** Battery Construction and Installation (cells, insulation, arrangement, compartment interior)	**Pt H, Ch 2, Sec 11/4:** Installation procedures and protection of corrosion (arrangement, cells, compartment interior, ventilation ducts, fan impellers)	All societies have the same basic topics and rules pertaining to this topic. Smart, common sense design with respect to electrical systems will satisfy all requirements for all societies.
313	BATTERIES & SERVICE FACILITIES - EMERGENCY POWER SOURCE	**Pt 4, Ch 8, Sec 2/5.9:** Emergency power source - Accumulator batteries (connections, services, load carrying, discharging rates)	**Pt 4, Ch 4, Sec 3-C303:** Batteries as emergency source of electrical power (SOLAS regulation - capacity, connection, services) **Pt 4, Ch 4, Sec 3-C4:** Transitional source of emergency power (location, services, times, capacity - SOLAS regulation)	**Pt 6, Ch 2, Sec 3/3.6:** Battery as emergency power source (loads, connections, services supplied) **Pt 6, Ch 2, Sec 3/3.7:** Transitional source of emergency electrical power (requirements, times, services) **Pt 6, Ch 2, Sec 3/3.10:** Accumulator Batteries (location, indicators)	**Pt H, Ch 3, Sec 3/3:** Kind and Performance of Emergency Electrical Power Source (loads, connections, services) **Pt H, Ch 3, Sec 3/4:** Transitional Source of emergency electrical power (operating performance, capacity, supply, services)	All these matters are based upon SOLAS regulations/requirements and not of the individual class society. Since this is the case, all societies are the same, with no significant difference.

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
313	BATTERIES & SERVICE FACILITIES - PROTECTION	**Pt 4, Ch 8, Sec 2/9.15:** Accumulator battery protection (overload, short circuit, fuse applicability, reverse current)	**Pt 4, Ch 4, Sec 3-D2:** Connection and protection of battery circuits (short-circuit, overload, connection arrangement, insulation, separation)	**Pt 6, Ch 2, Sec 6/1.5:** Batteries circuit protection (location relative to battery compartment) **Pt 6, Ch 2, Sec 6/1.6:** Protection omitting stipulations	**Pt H, Ch 2, Sec 3/12:** System Protection - Batteries (type, overload, short-circuit, location, emergency batteries)	ABS and NK essentially have the same requirements. LR does not have a specific section for batteries, but does make mention in general electrical system protection, but is very limited and only make statements, no guidance or rules to follow per se. DNV also has the basic same requirements as NK and ABS, but also include information on the connections of the batteries to the protective gear.
313	BATTERIES & SERVICE FACILITIES - BATTERY STARTING SYSTEMS	**Pt 4, Ch 8, Sec 2/11.11:** Battery starting systems (propulsion engines, auxiliary engines, miscellaneous requirements - include arrangements, capacity, monitoring, type)	**Pt 4, Ch 4, Sec 3-D3:** Starting arrangements for main engines (number, installation, connection, capacity) **Pt 4, Ch 4, Sec 3-D4:** Starting arrangements for auxiliary engines (requirements, circuitry, capacity, number)	**Pt 5, Ch 8, Sec 8/4:** Electric starting for oil engines (battery capacity, arrangement, number, storage, monitoring, alarms)	**Pt D, Ch 2, Sec 5/3.3:** Diesels Starting Arrangements - Battery supplied (number of sets, number of starts)	All have the same general base for battery starting requirements for main and auxiliary engines. DNV does goes the extra step to provide more information and detail than the others. No significant differences.
313	BATTERIES & SERVICE FACILITIES - CHARGING	**Pt 4, Ch 8, Sec 3/5.9:** Battery charging panels (charging rate, current reversal, instrumentation)	**Pt 4, Ch 4, Sec 3-D1:** Battery Charging Devices (recharge rate, independence, protection, arrangement) **Pt 4, Ch 4, Sec 3-D5:** Charging station for battery trucks (outlets, enclosures, ventilation)	**Pt 6, Ch 2, Sec 11/6:** Charging Facilities (monitoring, capacity, safety)	**Pt H, Ch 2, Sec 11/7:** Charging Facilities (charging means, protection, voltage control)	All rules incorporate appropriate protection means for the charger systems. All do differ on recharge time/capacity. LR does not state any requirements for recharge time except that it be prudent. NK states that suitable facilities be installed. ABS and DNV state quantities for recharge, with ABS at 80%/10 hrs and DNV at required starting capacity in 6 hrs. DNV also includes a section for battery truck recharging stations, which the other societies do not include.
313	BATTERIES & SERVICE FACILITIES - LOCATION / STORAGE	**Pt 4, Ch 8, Sec 4/5.3:** Battery storage location (battery room, deck boxes, different types)	**Pt 4, Ch 4, Sec 9-B5:** Battery Installation, Etc. (battery spaces, deck boxes, protection, coatings, materials, ventilation, cells, labels)	**Pt 6, Ch 2, Sec 11/3:** Battery Location (housing, vented batteries, type and arrangement, sealed, placards) **Pt 6, Ch 2, Sec 11/5:** Battery Space Ventilation (signage, natural ventilation requirements, inlet/outlet locations. Mechanical exhaust requirements, independence, fans, motors, boxes, air quantity, rate reductions)	**Pt H, Ch 2, Sec 11/3:** Location (separation, boxes, sizes, starting batteries, disallowed space) **Pt H, Ch 2, Sec 11/5:** Ventilation (compartment ventilation system, natural ventilation, mechanical ventilation, fan location, fan construction) Also see guidance for information, like air quantity rates	All have the same basics in the rules for the proper location/storage/ventilation of batteries and battery compartments. All mention corrosion-resistant measures, ventilation requirements, and size/space requirements. Designer concerns for spaces and required volumes/compartments are the same for all societies
314	POWER CONVERSION EQUIPMENT - TRANSFORMERS	see SWBS 311 for applicable information pertaining to transformers and international regulations				
314	POWER CONVERSION EQUIPMENT	**Pt 4, Ch 8, Sec 3/7:** Transformers and Converters (enclosures, rating, testing, name plates, semiconductor converters)	**Pt 4, Ch 4, Sec 6:** Static Convertors (transformers, static convertors with semiconductors)	**Pt 2, Ch 2 , Sec 9:** Converter equipment (transformers, semiconductor equipment, IEC std, temp rise)	**Pt H, Ch 2, Sec 10:** Transformers for Power and Lighting (scope, construction, temperature rise, voltage regulation, tests)	ABS has the least information and rules on this topic. NK does not have any text on semiconductor converters whereas the others do. LR the only society to make direct reference to IEC publications. In most cases, this type of equipment is type-approved selected and purchased, leaving details of the design out of the ship designer's hands.
320	***POWER DISTRIBUTION SYSTEMS***					

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
320	POWER DISTRIBUTION SYSTEMS - GENERAL	**Pt 4, Ch 8, Sec 2/7:** Distribution System Design (general, hull return systems, earthed AC, cable sizing, segregation, component circuits)	**Pt 4, Ch 4, Sec 3-E:** Distribution System Design (general	**Pt 6, Ch 2, Sec 5:** Supply and Distribution (systems, essential services, isolation and switching, insulated distribution systems, earthed distribution system, diversity factor, lighting circuits, motor circuits, motor control)	**Pt H, Ch 2, Sec 5:** Switchboards, Section Boards, and Distribution Boards (location, safety, construction, materials, busbars, equalizers, instruments, tests)	There are many parts of this topic that is spreads throughout the electrical sections within the text. LR offers the most information for the designer in terms of arrangements and system configuration.
320	POWER DISTRIBUTION SYSTEMS - SHORE CONNECTIONS	**Pt 4, Ch 8, Sec 2/11.1:** Shore connection (connection, cable, interlocking, instrumentation, earthing, notices)	**Pt 4, Ch 4, Sec 3-E2:** Shore Connections (connection, switchboard interface, ratings)	**Pt 6, Ch 2, Sec 4:** Temporary Shore Supply (connection, cables, switchboard interface, notices)	**Pt H, Ch 2, Sec 2/11:** Shore Connection (connection, cables, notices)	No significant differences between societies. All have very similar requirements.
321	SHIP SERVICE POWER CABLE	All cables are classified under the general "ELECTRIC CABLES" sections in the rules - SWBS 304				
322	EMERGENCY POWER CABLE SYSTEM	All cables are classified under the general "ELECTRIC CABLES" sections in the rules - SWBS 304				
323	CASUALTY POWER CABLE	All cables are classified under the general "ELECTRIC CABLES" sections in the rules - SWBS 304				
324	SWITCHGEAR AND PANELS (AND ASSOCIATED COMPONENTS)	**Pt 4, Ch 8, Sec 3/5:** Switchboards, Motor Controllers, Etc. (application, construction, assembly, components (busbars, circuit breakers, fuses, etc), main and emergency switchboards, battery charging panels, testing)	**Pt 4, Ch 4, Sec 4:** Switchgear and Control Gear Assemblies (construction, location, busbars, conductors, wiring, cable connections, adjustment devices, instruments, remotely operated switchboard. Auto start/stop of generators, earthing, distribution switchboard, control gear enclosures, testing)	**Pt 6, Ch 2, Sec 7:** Switchgear and control gear assemblies (general, busbars, circuit breakers, contactors, creepage, clearances, protection, distribution boards, earthing, fuses, handrails, AC generator instrumentation, instrument scales, labels, wiring, positioning, testing, disconnectors)	**Pt H, Ch 2, Sec 5:** Switchboards, Section Boards, and Distribution Boards (location, safety, construction, materials, busbars, equalizers, instruments, tests) **Pt H, Ch 2, Sec 6:** Circuit Breakers, Fuses, and Electromagnetic Contactors (circuit breakers, fuses, contactors) **Pt H, Ch 2, Sec 7:** Control Appliances (clearances, creepage, ambient conditions) **Pt H, Ch 2, Sec 8:** Controlgears for Motors and Magnetic Brakes (controlgears, magnetic brakes, temp rise, tests)	ABS-LR: Lloyd's allows copper and aluminum bus bars, ABS only copper. Other than that, no significant differences
330	***LIGHTING SYSTEM***					
330	LIGHTING SYSTEM - EMERGENCY LIGHTING	see SWBS 331		**Pt 6, Ch 2, Sec 17/1:** Emergency Lighting		
331	LIGHTING DISTRIBUTION	**Pt 4, Ch 8, Sec 2/7.13:** Lighting System - Design (definition, arrangement) **Pt 4, Ch 8, Sec 4/11:** Lighting Systems - Installation (location, reference above, cargo lighting link)	**Pt 4, Ch 4, Sec 3-E4:** Lighting Distribution (lit areas, arrangement, redundancy, rating, circuits, emergency considerations)	**Pt 6, Ch 2, Sec 5/7:** Lighting Circuits (rating, lighting points, switches, circuit configuration)	**Pt H, Ch 2, Sec 2/7:** Lighting Circuits - Design (rating, lighting points, redundancy)	ABS Rules speaks much less of specific rules/limitations than the other societies. Either allows for designer flexibility, or lack of design guidance for the designer. NK and LR both place limits on the number of lighting points per sub-circuit based on voltage (LR allows for much more points for the associated voltage than NK). NO significant differences in regard to emergency redundancy and topics like that.

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
332	LIGHTING FIXTURES (LAMPS and LAMPHOLDERS, LUMINARIES)	No specific rules on fixtures. All lighting system related entries for ABS in includes above - SWBS 331	**Pt 4, Ch 4, Sec 8-D:** Lampholders (standard approved types, locking, material reqt.) **Pt 4, Ch 4, Sec 8-E:** Luminaries (general, temperature rise, starting devices, capacitor discharge, voltage differences)	**Pt 6, Ch 2, Sec 12/2:** Lighting - General (lampholder material, fitting arrangement) **Pt 6, Ch 2, Sec 12/3:** Incandescent lighting (ratings, current, locking) Pt 6, Ch 2, Sec 12/4: Fluorescent Lighting (rating, current, mounting, discharge) **Pt 6, Ch 2, Sec 12/5:** Discharge Lighting (general, voltage considerations)	**Pt H, Ch 2, Sec 13:** Lighting Fittings (general, construction, ratings - IEC 60092 std, material, locking, arrangement, fluorescent lighting)	ABS does not include any rules/guidance for the topics found in the other society rulebooks. LR and DNV have a table for lampholder ratings and types. NK refers to a IEC standard for this. NK focus is on construction and components. LR and DNV are more design related.
340	***POWER GENERATION SUPPORT SYSTEMS***					
341	SSTG LUBE OIL	N/A	N/A	N/A	N/A	
342	DIESEL SUPPORT SYSTEMS	All internal combustion engines and engine related auxiliaries are found in SWBS 233.				
343	TURBINE SUPPORT SYSTEMS	All turbine engines and engine related auxiliaries are found in SWBS 231 (steam turbine) or SWBS 234 (gas turbines).				
390	***SPECIAL PURPOSE SYSTEMS - GENERAL***					
390	SPECIAL PURPOSE SYSTEMS - RADIO INSTALLATIONS	SWBS 441 - Radio Systems				See SWBS 441 numbers for radio systems
390	SPECIAL PURPOSE SYSTEMS - INTERIOR COMMUNICATIONS	SWBS 430 heading numbers for interior communications				See SWBS 43x numbers for interior communication related topics and rules
390	SPECIAL PURPOSE SYSTEMS	N/A	N/A	N/A	N/A	All special and unusual systems must be submitted for class approval. Rules address common systems only
398	ELECTRIC PLANT OPERATING FLUIDS	N/A	N/A	N/A	N/A	No specific rules for Electric Plant Operating Fluids. All necessary fluids for all machinery (I.e motors, engines, aux equipment are found in those applicable sections (if rules exist for those fluids/fluid systems)
399	ELECTRICAL PLANT REPAIR PARTS & TOOLS	**Pt 4, Ch 8, Sec 4/31**	**Pt 4, Ch 1, Sec 8**	**Pt 6, Ch 2, Sec 21**	**Pt H, Ch 3, Sec 8**	ABS does not require for class, but offers guidance; DNV recommends spares; LR leaves it up to owner/operator; NK requires specified spares

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
400	***COMMAND AND SURVEILLANCE, GENERAL***					Command and Surveillance is not typically associated with commercial ships. To apply to commercial designs, this section is based on bridge, control, and navigation aspects where applicable
401	GENERAL ARRANGEMENT - COMMAND AND SURVEILLANCE	No applicable section in main class rules, rules may be included in One-Man Operated Bridge section (not in possession). This falls in line with the other societies that have mention of this, but in special notation rules	**Pt 6, Ch 8:** Nautical Safety (bridge design related topics, working environment, bridge configuration, workstations, instrumentation location)	**Pt 7, Ch 9:** Navigational Arrangement for Periodic One Man Watch (workstations, field of vision, lighting, physical conditions, ambient environment, windows)	**Rules for Navigation Bridge Systems, Ch 3:** Bridge Layout and Bridge Working Environment (general, workstations arrangement, vibration, lighting, A/C, personnel safety)	These are not "main class" topics, but additional class notations. The basics for one-man watches and bridge arrangements are basically the same, no significant differences. Good engineering practice and ergonomics preside
402	SECURITY REQUIREMENTS	**Pt 4, Ch 9, Sec 6/7.3.2:** Automation and Control Computerized Systems - Hardware Security (input device security, i.e. keyboard) **Pt 4, Ch 9, Sec 6/3.1**: Automation and Control Computerized Systems - System Security (protection against software modification)	**Various throughout Pt 4, Ch 5:** Instrumentation and Automation (various mention in various section on the safeguarding of access and data)	**Various throughout Pt 6, Ch 1:** Control Engineering Systems (various mention of proper security measures and backup capability)	**Rules for Automated Remote Control Systems:** Various throughout.	No significant differences between societies. All state, somewhere in their texts, that proper security measures for safeguarding data and prohibiting unwanted access is to be taken. Some of these topics are under additional notations for class.
403	PERSONNEL SAFETY	No specific section in regard to personnel or crew safety in relation to command and surveillance issues	No specific section in regard to personnel or crew safety in relation to command and surveillance issues. But, **Pt 5, Ch 10 - Reefer Cargo** vessels does include various topics in relation to personnel safety, but not command and surveillance.	**Pt 6, Ch 3, Sec 8/1:** Personnel Safety Equipment (access locks, emergency escape capability, lighting, clothing and associated equipment for specific spaces and systems, tools, wash stations) **Pt 6, Ch 3, Sec 8/1:** Personnel Warning Systems (monitors, audible, authorized access control, alarms) **These topics** are related to Reefer installations	No specific section in regard to personnel or crew safety in relation to command and surveillance issues. **Rules for Cargo Reefer Installations** have same basic safety items for personnel as other societies See SWBS 401 for bridge personnel safety	All societies do not have any topics on personnel safety, except LR, for command and surveillance-type activities. The societies do have dedicated topics in respect to refrigerated vessels and spaces however.
403	PERSONNEL SAFETY - LIGHTING	See SWBS 330 - LIGHTING SYSTEMS - EMERGENCY LIGHTING				
404	RADIO AND TRANSMISSION LINES	See SWBS 441 - RADIO SYSTEMS for all issues/requirements related to Radios and Radio associated equipment				
405	ANTENNA REQUIREMENTS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES (no requirements for antennas)				
406	GROUNDING AND BONDING	**see SWBS 303**		**Pt 6, Ch 2, Sec 1/12:** Bonding for the Control of Static Electricity (applicability requirements, strap sizing)		In terms of electrical equipment and associated items, see SWBS 303 - Electrical Protective Devices for possible applicable sections in addition to the listing here.
407	ELECTROMAGNETIC INTERFERENCE REDUCTION (EMI)	**Pt 4, Ch 9, Sec 5/3.1**: Electromagnetic Avoidance for Control and Automation (states that unusual electromagnetic source to be avoided locationwise for equipment) **Various small mention** throughout text that items should avoid EMI, but no specifics on how to	**Pt 4, Ch 4, Sec 2-E:** Electromagnetic Noise and Interference (harmonic distortion limits, equipment design and operating limits)	**Pt 6, Ch 1, Sec 2/10.9 and 10.10:** Data Communication Links (protection from electromagnetic interference) **Pt 6, Ch 2, Sec 1/7:** Quality of Power Supplies (harmonic distortion limits)	No specific section dedicated to EMI or EMI-related subjects	DNV has a specific section for electric equipment with respect to EMI. They also provide set harmonic distortion limits for equipment. Check also SWBS 303 for any possible additions to the sections/information listed here regarding EMI protection.
408	SYSTEM TEST REQUIREMENTS	Various throughout individual systems	Various throughout individual systems	Various throughout individual systems	Various throughout individual systems	Each individual system, or group of systems will have their own classification society test/trial procedure. The test procedures are a limited impact issue with designers. All societies follow the general same test procedures and thresholds.
409	COMBAT SYSTEM GENERAL REQUIREMENTS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
410	***COMMAND AND CONTROL SYSTEMS***					
411	DATA DISPLAY GROUP	**Pt 4, Ch 6, Sec 7/5:** Hardware - visual display unit (general, size, color, control, alarm display, propulsion monitoring)	**Pt 4, Ch 5, Sec 6-C2:** Visual Display Units for User Interfaces (resolution, refresh rate, glare, general requirements) **Pt 4, Ch 5, Sec 6-D:** Additional requirements to screen based systems (computer dialogue, application screen views)	**Pt 6, Ch 1, Sec 2/9:** Programmable electronic systems - General requirements (display properties, equipment properties)	No section found	In respect of items that must be displayed on consoles for monitoring purposes, all societies are the same, no significant difference. ABS and DNV have dedicated section to the ergonomics for the actual display, where the others do not, at least in main class rules.

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
412	DATA PROCESSING GROUP	**Pt 4, Ch 6, Sec 6:** Control and Automation - Computerized Systems (system requirements, integrated systems, hardware) **Pt 4, Ch 6, Sec 7:** Control and Automation - Equipment (environment, electrical components, tests)	**Pt 4, Ch 5:** Instrumentation and Automation (classification, definitions, documentation, tests, system configuration, unavailable time, failure response, emergency operations, system elements, computers, software, hardware, installation, electrical aspects, user interface)	**Pt 6, Ch 1:** Control Engineering Systems (general requirements, essential features, individual system requirements, tests)	**Rules for Automated Remote Control Systems, Ch 3, Sec 2/7:** Computers and Computerized Systems (requirements, backup, reliability)	No significant differences exist. Some societies have mention of this under special/additional notations
413	DIGITAL DATA SWITCHBOARDS	All switchboard information is provided in SWBS 324, please reference				
414	INTERFACE EQUIPMENT	N/A	**Pt 4, Ch 5, Sec 6:** User Interface (work environments, worker/machine interface)	**Pt 6, Ch 1, Sec 6:** Integrated computer control - operator interface (terminals, equipment, connection) Note: this is only required for the "ICC" notation	N/A	Interface equipment is a large and broad topic. This can mean many different things. Here, it is taken as user interface
415	DIGITAL DATA COMMUNICATIONS	N/A	N/A	N/A	N/A	
417	COMMAND AND CONTROL ANALOG SWITCHBOARDS	All switchboard information is provided in SWBS 324, please reference				
420	***NAVIGATION SYSTEMS***					The only mention to navigational systems is in special notation rules for bridge systems. The societies all seem to be the same in this respect. Many of the topics are SOLAS regulated due to the navigation/safety relation
421	NON-ELECTRICAL NAVIGATION AIDS	No applicable section in main class rules, rules may be included in One-Man Operated Bridge section (not in possession). This falls in line with the other societies that have mention of this, but in special notation rules	**Pt 6, Ch 8, Sec 4:** Equipment Carriage Requirements (compasses) Not main class, but Nautical Safety and special bridge notation	**One-man Watch / Integrated Bridge Navigation System Notation** (for special notation, references gyro compasses and number) nothing in main class	**Rules for Navigation Bridge Systems, Ch 4:** Navigational Equipment (compasses, and other navigational equipment)	SOLAS addresses compasses, but not main class society rules. Mention to compasses are made in special notation sections in relation to bridge design and one-man watches.
422	ELECTRICAL NAVIGATION AIDS	See SWBS 426 for ALL electrical navigational elements				
423	ELECTRICAL NAVIGATION SYSTEMS - RADIO	N/A	N/A	N/A	N/A	No specific section, just mention of basic radio communications of VHF/UHF for communication with shore bases and local parties must be included in the navigation package for the special notations
424	ELECTRICAL NAVIGATION SYSTEMS - ACOUSTICAL	N/A	N/A	N/A	N/A	No specific section, just mention of echo sounding capabilities must be included in the navigation package for the special notations
425	PERISCOPES	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
426	ELECTRICAL NAVIGATION SYSTEMS	**Pt 4, Ch 8, Sec 2/11.3:** Navigation light system (feeder, branch circuit, duplicate lamps, control and indication panel)	**Pt 4, Ch 8, Sec 3:** Safety of Navigation - Navigational Aids (technical requirements, publications and records - SOLAS text)	**Pt 6, Ch 2, Sec 14:** Navigation and maneuvering system, (steering gear, thruster system, navigation lights, navigational aids) **Additional Notation: Pt 7, Ch 9, Sec 5: Integrated Bridge Navigation System** (general, equipment, interface, alarms, power supply)	**Pt H, Ch 3, Sec 6/1:** Navigation Lights (connections, controlled, switches, panels) **Additional Notation: Rules for Navigation Bridge Systems** (scope, general, power supply, equipment, equipment illumination)	Navigational aids and related equipment (electrical, emergency backup, etc) are regulations, more than society rules. This dictates that the society rules are very similar between societies, and no significant differences exist. DNV has verbatim text from SOLAS and the most complete information on the topic. ABS limits their discussion to lights only (possibly more rules in the auxiliary bridge publication). NK and LR have very similar requirements for their additional notations. In LR case, they state that all navigational equipment must meet IMO regulations, but their rules do not necessarily address all the applicable SOLAS regulations. Same with NK.
427	INERTIAL NAVIGATION SYSTEMS	N/A	N/A	N/A	N/A	
428	NAVIGATION CONTROL MONITORING	N/A	N/A	N/A	N/A	All related subject matter is contained in the special bridge notation sections. There are no significant differences between the societies. All have the same basis for bridge control and monitoring
430	***INTERIOR COMMUNICATIONS***					
431	SWITCHBOARDS FOR IC SYSTEMS	**SEE SWBS 324 for general switchboard information**				Rules refer back to electrical engineering section for general switchboards (SWBS 324), but some societies will provide additional rules/guidance for special use switchboards, like IC system switchboards embedded in the rules for IC systems)

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
432	TELEPHONE SYSTEMS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				Not an inclusive classification society topic. Any references to telephones would be in SWBS 433. Communications is highly dependant upon SOLAS/IMO regulations
433	ANNOUNCING SYSTEMS	**Pt 4, Ch 8, Sec 2/11.5:** Interior Communication Systems (general, engine order telegraph, voice communication, public address system, power supply)	**Pt 4, Ch 9, Sec 2-A:** Interior Communications - General Requirements (application, classification, documentation, testing, terms, definitions) **Pt 4, Ch 9, Sec 2-B2:** Interior communications - Ship Requirements - public address system (all SOLAS quoted text)	**Pt 6, Ch 2, Sec 17/3:** Public address system (circuit feeds, amplifier ratings, loudspeaker ratings, interference elimination, alarm features/requirements)	**Pt H, Ch 3, Sec 6/5:** On-board communications (refer to SOLAS, power supply)	No significant differences. NK has the least information on this topic, making only a reference to SOLAS for onboard communications. The others have section, but have SOLAS references as well, but other information is similar.
434	ENTERTAINMENT & TRAINING SYSTEMS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
435	VOICE TUBES & MESSAGE PASS SYSTEMS	Not generally used on modern commercial vessels. See SWBS 433 for voice/message communications				
436	ALARM SAFETY & WARNING SYSTEMS	**Pt 4, Ch 8, Sec 2:** Manually operated alarms (general emergency alarm system, engineers' alarm, reefer space alarm, elevator's alarm, power supply) **Also see SWBS 433**	**Pt 4, Ch 9, Sec 2-B2:** Interior communications - Ship Requirements - public address system (all SOLAS quoted text)	**Pt 6, Ch 2, Sec 17/2:** General emergency alarm system (audible warning system, operation, shutoff, circuit feeds, sound pressure levels, signal frequencies, multiple alarms/sounds)	**Pt H, Ch 3, Sec 6/5:** On-board communications (refer to SOLAS, power supply)	General alarm systems are regulated by regulations, not classification society, which leads to no significant differences. Even in the alarm design and arrangements (of systems and machinery),, regulatory bodies play a large role in determining the types and configurations of the alarms to promote nautical safety.
437	INDICATING ORDER & METERING SYSTEMS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
438	INTEGRATED CONTROL SYSTEMS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				Not applicable in terms of interior communications. See other SWBS for control systems for machinery and such.
439	RECORDING & TV SYSTEMS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
440	***EXTERIOR COMMUNICATIONS***					
441	RADIO SYSTEMS	**Pt 4, Ch 8, Sec 2/5.5:** Emergency requirements for radio systems	**Pt 4, Ch 9, Sec 1-B:** GMDSS Ship Requirements (functional requirements, radio installations, radio equipment - general, watches, energy sources, performance standards, maintenance requirements, records, life saving appliances) All SOLAS and GMDSS required regulations per IMO	**Pt 6, Ch 2, Sec 4/3.6:** Emergency requirements for radio systems	**Pub # 99-470:** Rules for Radio Installations	All societies either make reference to or state their rules are IMO GMDSS compatible. GMDSS is the ruling document in respect to radios and related items
442	UNDERWATER COMM SYSTEMS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
443	VISUAL & AUDIBLE SYSTEMS	No applicable section in reference to exterior visual/audible systems	No applicable section in reference to exterior visual/audible systems	See SWBS 433 for public address system (includes reference to exterior spaces)	No applicable section in reference to exterior visual/audible systems	No society except LR has explicit rules or information on a exterior communication or PA system. A designer would use common sense to make the necessary and prudent design of the PA / communication system to possibly include exterior spaces is warranted.
444	TELEMETRY SYSTEMS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
445	TTY & FACSIMILE SYSTEMS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
446	SECURITY EQUIPMENT	Only "security-type" equipment for communications falls under the alarm and safety topics				There are international regulations with respect to monitoring access to controlled spaces such and sounding an audible alarm
450	***SURVEILLANCE SYSTEMS (SURFACE)***					General not applicable to the commercial world.
451	SURFACE SEARCH RADAR	No applicable section in main class rules, rules may be included in One-Man Operated Bridge section (not in possession). This falls in line with the other societies that have mention of this, but in special notation rules	**Pt 6, Ch 8, Sec 6-F:** Radar Systems - General Bridge Equipment - Additional Class for Bridge Navigation and Nautical Aids (general, IMO standard for navigational radar, display effective diameter, radar facilities, switching)	**Pt 6, Ch 8, Sec 6-F:** Radar Systems (for special notation for bridge design and one-man watch, not part of general class) - IMO reference, display characteristics, requirements, switching	**Rules for Navigation Bridge Systems, Ch 4:** Navigational Equipment (radar, operating band, plotters)	All of these requirements are not necessarily for general main class vessels, but additional class notations.
452	AIR SEARCH RADAR (2D)	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
453	AIR SEARCH RADAR (3D)	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
454	AIRCRAFT CONTROL APPROACH RADAR	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
455	IDENTIFICATION SYS (IFF)	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
456	MULTIPLE MODE/FUNCTION RADAR					
459	SPACE VEHICLE ELECTRONIC TRACKING	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
460	***SURVEILLANCE SYSTEMS (UNDERWATER)***	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
470	***COUNTERMEASURES***	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
480	***FIRE CONTROL SYSTEMS***	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
490	***SPECIAL PURPOSE SYSTEMS***					
491	ELECTRICAL TEST CHECK MONITOR SYS	See SWBS 300 group for electrical related items/topics				
492	FLIGHT CONTROL AND INSTRUMENT LANDING SYSTEMS	NOT APPLICABLE TO COMMERCIAL CONSTRUCTION / SOCIETY RULES				
493	NON COMBAT DATA PROCESS					No specific rules on computers, other than dedicated special use computers.
494	METEOROLOGICAL SYSTEMS	No applicable section	**Pt 7, Ch 3, App B-3:** Meteorological Services (SOLAS requirement, this is a responsibility of the governments to provide and collect weather information for ships in jurisdiction)	No applicable section	No applicable section	**Ch V, Reg 4:** Meteorological Services (this is a responsibility of the governments to provide and collect weather information for ships in jurisdiction) **Not a design issue per se**, but more a disclosure of the responsibility of governments to provide and collect weather data from ships in their jurisdiction. DNV is verbatim text from SOLAS. ABS, LR, and NK do not have references to this topic, at least in their main class rules.

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
500	*AUXILIARY SYSTEMS, GENERAL*	Part 4 - General	Vol 1, Part 4 - General	Part 5 - General	Part D - General	
501	GENERAL ARRANGEMENTS - AUXILIARY SYSTEMS DRAWINGS	Under each machinery/auxiliary topic in rules are the requirements for drawings/documentation for that topic	Under each machinery/auxiliary topic in rules are the requirements for drawings/documentation for that topic	Under each machinery/auxiliary topic in rules are the requirements for drawings/documentation for that topic	Under each machinery/auxiliary topic in rules are the requirements for drawings/documentation for that topic	There are very few differences in the reqwuired documentation and/or drawings that are to be submitted to the society. Of course, some require a bit more or a bit less on certain topics, but for the large majority or documentation, they are applicable/acceptabvle to all societies.
502	AUXILIARY MACHINERY	**Pt 4, Ch 1:** General **Pt 4, Ch 2:** Prime Movers (diesel engines, turbochargers, gas turbines, steam turbines) **Pt 4, Ch 3:** Propulsion & Maneuvering Machinery (gears, propulsion shafting, propellers, steering gears, thrusters) **Pt 4, Ch 5:** Deck and Other Machinery (anchor windlass) **Pt 4, Ch 6:** Piping Systems **Pt 4, Ch 7:** Fire Safety Systems **Pt 4, Ch 8:** Electrical Systems (SWBS 300 group) **Pr 4, Ch 9:** Remote Propulsion Control and Automation	**Pt 4, Ch 1:** Machinery and Systems, General (materials, design principles, ship piping systems, machinery piping systems, pumps, workmanship, spare parts) **Pt 4, Ch 2:** Propulsion and Auxiliary Machinery (diesels, steam turbines, gas turbines, gear transmissions, shafting and vibration, propellers, thrusters, turbochargers, compressors) **Pt 4, Ch 3:** Boilers, Pressure Vessels and Incinerators **Pt 4, Ch 4:** Electrical Installations (SWBS 300 group) **Pt 4, Ch 5:** Instrumentation and Automation **Pt 4, Ch 5:** Fire Protection, Detection, and Extinction **Pt 4, Ch 7:** Coal Fired Boilers **Pt 4, Ch 8:** Navigation Safety **Pt 4, Ch 9:** GMDSS and Internal Communication	**Pt 5, Ch 1:** General Requirements **Pt 5, Ch 2:** Oil Engines **Pt 5, Ch 3:** Steam Turbines **Pt 5, Ch 4:** Gas Turbines **Pt 5, Ch 5:** Gearing **Pt 5, Ch 6:** Main Propulsion Shafting **Pt 5, Ch 7:** Propellers **Pt 5, Ch 8:** Shaft Vibration & Alignment **Pt 5, Ch 9:** Ice Navigation Strengthening **Pt 5, Ch 10:** Steam Plants / Pressure Vessels **Pt 5, Ch 11:** Other Pressure Vessels **Pt 5, Ch 12:** Piping Design Requirements **Pt 5, Ch 13:** Ship Piping Systems **Pt 5, Ch 14:** Machinery Piping Systems **Pt 5, Ch 15:** Oil Tanker Piping **Pt 5, Ch 16:** Spare Gear for Machinery **Pt 5, Ch 17:** Fusion Welding **Pt 5, Ch 18:** Integrated Propulsion System **Pt 5, Ch 19:** Steering Gear **Pt 5, Ch 20:** Azimuth Thrusters	**Pt D, Ch 1:** General **Pt D, Ch 2:** Diesel Engines **Pt D, Ch 3:** Steam Turbines **Pt D, Ch 4:** Gas Turbines **Pt D, Ch 5:** Power Transmission Systems (gears) **Pt D, Ch 6:** Shaftings **Pt D, Ch 7:** Propellers **Pt D, Ch 8:** Torsional vibration of Shaftings **Pt D, Ch 9:** Boilers and Incinerators **Pt D, Ch 10:** Pressure Vessels **Pt D, Ch 11:** Welding for Machinery Installations **Pt D, Ch 12:** Pipes, Valves, Pipe Fittings, and Auxiliaries **Pt D, Ch 13:** Piping Systems **Pt D, Ch 14:** Tanker Piping Systems **Pt D, Ch 15:** Steering Gears **Pt D, Ch 16:** Windlasses and Mooring Winches **Pt D, Ch 17:** Refrigeration Equipment **Pt D, Ch 18:** Automatic and Remote Control **Pt D, Ch 21:** Spare Parts **NO chapters 19/20**	This SWBS just is a top level listing of the individual topics/sections in each society in relation to the auxiliary machinery SWBS as a whole. Individual auxiliary systems and requirements are addressed in their applicable SWBS number category. All societies address the same main topics as displayed in the cells to the left. This is not a comparison of technical issues, but merely a point of reference to the beginning of the remainder of the SWBS 500 group which follows.
503	PUMPS	**Pt 4, Ch 6, Sec 1/7.3:** Pumps (required pumps to be certified by surveyor, required tests) No design information	**Pt 4, Ch 1, Sec 6-B:** Pumps (describes pumps to be certified, the tests, compatibility with fluid)	No specific "pump" section. Various references made throughout texts.	No specific "pump" section. Various references made throughout texts.	In general, pumps are type-approved equipment, Large number of references to pumps are made in the texts in various system that use pumps. In general, all the societies are basically the same, and no significant differences exist pumpwise. If differences exist for system pumps, it will be mentioned under that system in the SWBS index.
504	INSTRUMENTS AND INSTRUMENT BOARDS	**See SWBS 410 group or individual system for this topic**				This a a very broad topic. In the individual systems, any significant differences between societies for instrumentation and boards will be menmtioned. Also the 410 group includes information on this topic in a more bvroad sense
505	GENERAL PIPING REQUIREMENTS - GENERAL	**Pt 4, Ch 6, Sec 1:** Piping Systems - General Provisions	**Pt 4, Ch 1, Sec 6:** Pipes, Pumps, Valves, Flexible Hoses, and Detachable Pipe Connections	**Pt 5, Ch 12:** Piping Design Requirements	**Pt D, Ch 12:** Pipes, Valves, Pipe Fittings, and Auxiliaries	
505	GENERAL PIPING REQUIREMENTS - SCANTLINGS	**Pt 4, Ch 6, Sec 2/5:** design (thickness of pipes, alternative equatiion)	**Pt 4, Ch 1, Sec 6-A2:** Minimum wall thickness **Pt 4, Ch 1, Sec 6-A3:** Calculation of wall thickness on pipes subject to internal pressure	**Pt 5, Ch 12, Sec 2:** Carbon and low alloy steels (wall thickness) **Pt 5, Ch 12, Sec 3:** Coper and copper alloys (thicknesses)	**Pt D, Ch 12, Sec 2:** Thickness of pipes (wall thickness, pressure dependant and table minimums, corrosion allowances)	All are the same for the pressure based thickness calculation due to the uniform laws of mechanics and fluids. Some societies differ on the small additions to the calculation, whether it be corrosion, manufacturing tolerances, etc) ABS also has an "alertnative" equation for wall thickness calculations, but does not state the conditions of its use. LR has different calculation dependant upon the material type

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
505	GENERAL PIPING REQUIREMENTS: VALVES	**Pt 4, Ch 6, Sec 2/5.9:** Valves	**Pt 4, Ch 1, Sec 6-C:** Valves	**Pt 5, Ch 12, Sec 6:** Valves	**Pt D, Ch 12, Sec 3:** Construction of Valves and Pipe Fittings (general, special). Only states acceptable standard to be used	For many of these "sub-topics" uner general piping, societies will not have dedicated sections. These cells are blank. This subtopic may be mentioned throughout the text or built in someplace else. In general, all piping requirements are the same. There are no major differences to disrupt the regular piping design process between societies. Good engineering practice will dictate the design, with assistance from the societies and regulatory bodies, which also are involved for certain pipes and systems. For actual pipes, the ANSI standards are widely used and accepted.
505	GENERAL PIPING REQUIREMENTS: FLEXIBLE HOSES	**Pt 4, Ch 6, Sec 2/5.7:** Flexible and expansion joints	**Pt 4, Ch 1, Sec 6-D:** Flexible Hoses (general., installation)	**Pt 5, Ch 12, Sec 7:** Flexible Hoses (general, application)	**Pt 5, Ch 15, Sec 4/6:** Flexible Hoses for use w/ steering gear construction	
	GENERAL PIPING REQUIREMENTS: PLASTIC PIPES	**Pt 4, Ch 6, Sec 3:** Plastic Piping	**Pt 4, Ch 1, Sec 6-A7:** Plastic Pipes	**Pt 5, Ch 12, Sec 5:** Plastic Pipes	No applicable section	
505	GENERAL PIPING REQUIREMENTS: MATERIALS	**Pt 4, Ch 6, Sec 2/2:** Metallic Piping - Materials	**Pt 4, Ch 1, Sec 2-C:** Piping System Materials	**Pt 5, Ch 12, Sec 1/6:** Materials **Also,** following sections (i.e. carbon and low alloy steel section (relates to design of pipe of this type of material, not specific on the material)	**Pt D, Ch 12, Sec 1/4:** Materials	
505	GENERAL PIPING REQUIREMENTS: DESIGN PRINCIPLES GENERAL	**Pt 4, Ch 6, Sec 1:** Piping Systems - General Provisions (general, definitions, piping system classes, piping system component certification, plans and data for submittal)	**Pt 4, Ch 1, Sec 3-A**	**Pt 5, Ch 12, Sec 1:** General Piping Design Requirements (application, symbols, pressure, temperature, class)	**Pt D, Ch 12, Sec 1:** Pipe General (scope, terminology, class, material limitations, special materials	
505	GENERAL PIPING REQUIREMENTS: BONDING	See SWBS 406 - BONDING AND GROUNDING				
506	OVERFLOWS	**Pt 4, Ch 6, Sec 4/9.5:** Tank Overflows (general, pipe size, discharge, pipe thickness)	**Pt 4, Ch 1, Sec 4-K3 to K4:** Overflow Pipes (general, sectional area, configuration)	**Pt 5, Ch 13, Sec 10/9 to 10/10:** Overflows (general, configuration, sectional area)	**Pt D, Ch 13, Sec 7:** Overflow Pipes (general, sectional area, special purpose, protection)	
506	VENTS	**Pt 4, Ch 6, Sec 4/9.3:** Tank vents (general, pipe height, pipe thickness, pipe size, termination, protection)	**Pt 4, Ch 1, Sec 4-K1 to K3:** Air pipes (general, sectional area, arrangement, termination) **Pt 3, Ch 1, Sec 11-I:** Tank Access, Ullage, and Ventilation Openings (general, air pipe height and wall thickness)	**Pt 5, Ch 13, Sec 10/4 to 10/8:** Air pipes (general, termination, diaphrams, closing, pipe size) **Pt 3, Ch 12, Sec 3:** Air and sounding pipes (structural consideration, height of air pipe, closing configurations)	**Pt D, Ch 13, Sec 7:** Air Pipes (general, configuration, sectional area, height of pipe)	ABS is the only society to outright suggest pipe wall thickness. All other aspects are the same.
506	SOUNDING TUBES	**Pt 4, Ch 6, Sec 4/11:** Means of sounding (general, installation, pipe size, pipe thickness, materials, closing device, tank type specifics)	**Pt 4, Ch 1, Sec 4-K5 to K8:** Sounding pipes (general, sectional area, special considerations	**Pt 5, Ch 13, Sec 10/11 to 10/16:** Sounding pipes (arrangement,. Termination, short pipes, elbow pipes, striking plates, pipe size) **Pt 4, Ch 12, Sec 3:** Air and sounding pipes (closing configurations, striking plate)	**Pt D, Ch 13, Sec 7:** Sounding Pipes (general, configuration, construction)	ICLL for height of air pipes (all societies uniform). ABS minimum pipe wall thickness depends upon usage. LR and DNV have general minimums regardless of use. NK has no mention of pipe wall thickness in this section (in general piping section D-12), which is same as ABS.. Also, no "40 degree angle" automatic closing rule in NK.
507	AUXILIARY AND PIPING DESIGNATIONS AND MARKINGS	**Pt 2, Ch 3, Sec 12/7:** Steel Piping Marking (manufacturer, grade, test pressure, forming method, strength, standard compliance) **Pt 4, Ch 6, Sec 1/7.1.3:** General Piping Identification (same as above) **Pt 4, Ch 6, Sec 3/5.17:** Plastic Piping Identification (same as above)	**Pt 2, Ch 1, Sec 1-C1:** Identification of Materials for pipes and tubes (traceable, material, manufactures name) **Pt 4, Ch 1, Sec 3-A206:** Sea Connection markings **Pt 4, Ch 1, Sec 4-K302:** Overflow storage tank capacity signboard	**Pt 5, Ch 13, Sec 10/3:** Air, Overflow, and sounding Pipes - Nameplates (location of nameplate for air and sounding pipes)	**Pt K, Ch 4, Sec 1/9:** Steel Pipe Marking (manufacturer, grade, size stipulations) **Pt D, Ch 13, Sec 2/1.8:** Distinction of Pipe Lines (color marking, name plates for valves, fire extinguishing valves, air pipes, sounding pipes, overflow pipe tops)	Pipe diameter: same for all, except DNV has larger diameter reqt for HFO sounding pipes. ABS & NK are only ones to specifically state rules for pipe wall thickness. ABS has no discussion of "short sounding pipes" (DNV and LR) or "elbow sounding pipes" (LR)

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
508	THERMAL INSULATION FOR PIPING AND MACHINERY	**Various throughout Part 4:** states that hot surfaces are to be properly insulated with oil-resistant material **Pt 4, Ch 6, Sec 5/11.3:** Exhaust Gas Piping Insulation (require effective insulation)	**Pt 4, Ch 1, Sec 3-A5:** General Design Principles for Machinery and Systems (hot surfaces must be effectively insulated)	Various throughout Part 5. Keep away and insulated form hot surfaces. NO rules on specific insulations or configuration	Various throughout Part D. Keep away and insulated form hot surfaces. NO rules on specific insulations or configuration	This particular aspect has very limited impact on the design and design exercises of the ship designer. These are details to be met by manufacturers or draftsmen. Overall, the societies have the same marking/nameplate/stamping requirements for general piping. Several small differences exist in terms of specific markings (e.g. sounding tubes).
509	THERMAL INSULATION FOR VENT AND A/C DUCTS	no applicable section	no applicable section	no applicable section	no applicable section	Society rules are virtually non-existent for HVAC and HVAC related topics for climate control.
510	***CLIMATE CONTROL***					
511	COMPARTMENT HEATING SYSTEMS	N/A	**Pt 4, Ch 4, Sec 8-F2:** Electric Space Heaters (type, installation, temperature rises, construction, "live" parts) **Pt 4, Ch 4, Sec 8-F3:** Space Heaters with A/C cabinets (installation, location, thermostat)	N/A	N/A	Not typically a classification society design topic. In many cases the society will have a list of approved equipment, which may include an actual commercial system. But the rules do not directly address topics like heating and air conditioning for crew.
512	VENTILATION SYSTEM	**Pt 3, Ch 2, Sec 17/9:** Ventilators (construction, height, means for closing)	**Pt 3, Ch 1, Sec 11-H:** Ventilators (regulations (ICLL), coaming cthickness, arrangement and support)	**Pt 3, Ch 12, Sec 2:** Ventilators (general, coamings, closing appliances) Not necessarily for climate control, but for space breathing and general air/gas ventilation	**Pt C, Ch 23, Sec 3:** Ventilators (coaming height, coaming thickness, connection, cowls, closing appliance, deckhouse ventilators)	The "ventilator" terminology is not necessarily directly related to climate control features in this section. Regulations are spelled in the ICLL for this topic, and hence, all societies are generally the same. Societies do not make reference to climate, HVAC-type ventilation
513	MACHINERY SPACE VENTILATION SYSTEM	SEE SWBS 512				
514	AIR CONDITIONING SYSTEM	No references to climate control or A/C systems in ABS main class rules	**Pt 5, Ch 12, Sec 3:** A/C & comfort class requirements. Not main class, additional notation rules. Has temperature thresholds, and space requirements. Actual systems from international stanadrds referenced.	No references to climate control or A/C systems in LR main class rules	No references to climate control or A/C systems in NK main class rules	Societies havce mention of A/C and enviromnmetal control issues in that in event of main failure, means to control atmosphere in designated space is to be present. Only DNV, with their comfort class notation, goes in-depth into climate control and environmentall controlled spaces for crew. References are made in the bridge notation sections that A/C is required in the bridge
515	AIR REVITALIZATION SYSTEMS (SUBMARINES)	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION / DESIGN				
516	REFRIGERATION SYSTEM	**Pt 6, Ch 2:** Vessels Intended to Carry Refrigerated Cargoes (various sections refer to the reefer components and systems) Includes many compulsory requirements from regulation bodies. Meant for additional notation only, but can be used as guide if desired	**Pt 5, Ch 10:** Ships for Carriage of Refrigerated Cargoes (note: mentions in main class text that small reefer plants need only follow the safety rules set out in this section, 5-10, sets limit at 7.5kW systems and lower).	**Pt 7, Ch 1:** Controlled Atmosphere Systems (general, documentation, controlled spaces and adjacent spaces, gas systems, humidity, electrical installation, control and alarms, safety, tests) this section is for vessels requesting the Controlled Atmosphere notation (CA) within Lloyds. But can be used as a guide for general reefer systems	**Pt D, Ch 17:** Refrigeration Equipment (general, machinery design, controlled atmosphere system) **Rules for Cargo Refrigeration Installations** (auxiliary publication, includes special notations)	All societies have auxiliary texts and notations for reefer systems and dedicated refrigerated cargo carrying vessels in addition to any other listings here. These are not part of main class rules. There are many regulation type compulsory requirements in reference to refrigerated vessels.
517	WASTE HEAT BOILER SYSTEM	SEE SWBS 221				Societies state that ingeneral, waste heat boilers are to conform with the rules for fired boilers. No specific rules for waste heat boilers.
520	***SEA WATER SYSTEMS***					
521	FIREMAIN & SW FLUSHING SYS	See SWBS 555 for firemain information				
522	SPRINKLER SYSTEM	See SWBS 555 for fire fighting systems, including sprinklers				
523	WASHDOWN SYSTEM	NO APPLICABLE RULES FOUND IN ANY CLASS SOCIETY ORGANIZATION				
524	AUXILIARY SEAWATER SYSTEM	N/A	N/A	N/A	N/A	See individual system for any comments on the society or the comparison between them. In commercial arena, there is no such stand alone "auxiliary seawater system"

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
526	SCUPPERS & DECK DRAINS	**Pt 3, Ch 2, Sec 17/5:** Freeping Ports (area, sheerless vessels, trunks, open superstructures, details)	**Pt 3, Ch 1, Sec 11-K:** Scuppers, Inlets, and Discharges (ICLL regulation, ICLL intrepretation, number, size, arrangement, scantling information)	**Pt 3, Ch 12, Sec 4:** Scuppers and sanitary discharges (number, size, arrangement, scantlings, closing appliances, rubbish/offal chutes and other discharges, material)	**Pt D, Ch 13, Sec 4:** Scuppers, sanitary discharges, etc (general, size, number, closing arrangement, other discharges)	Also see SWBS 528 for more drainage related sections and comments. ABS only society not to have a dedicated "scupper" section in text. DNV provides text from the ICLL on scuppers and discharges. These regulations are not spelled out in the other texts, but their rules will meet the regulations anyhow. DNV and LR include more information with respect to pipe wall thickness. ABS includes no mention of wall thickness in this section
527	FIREMAIN ACTUATED SERVICES - OTHER	N/A	N/A	N/A	N/A	No references to firemain actuated systems or services in classification society rules. All references to firemains are referenced in SWBS 555
528	PLUMBING DRAINAGE	**Pt 4, Ch 6, Sec 4/3:** Gravity Drain Systems (general, protection from sea water ingress, cargo spaces on or above freeboard deck, other than cargo spaces, non-watertight spaces) Also related information in: **Pt 4, Ch 6, Sec 4/5:** Bilge System	**Pt 4, Ch 1, Sec 4-B:** Basic requirements for4 drainage of compartments and tanks (general, water ingress prevention **Pt 4, Ch 1, Sec 4-C:** Cargo hold drainage (general, alternative cargoes) **Pt 4, Ch 1, Sec 4-D:** Cargo Deck Space drainage (general, foam spaces) **Pt 4, Ch 1, Sec 4-E:** Dry compartments other than category A machinery and cargo spaces (general, auto sprinkler spaces) **Pt 4, Ch 1, Sec 4-F:** Category A machinery space drainage (general, bilge suction, special spaces)	**Pt 5, Ch 13, Sec 3:** Drainage of compartments, other than machinery space (general, cargo holds, holds and deep tanks for alternative carriage of liquid or dry cargo, tanks and cofferdams, for and after peaks, spaces above fore/after peaks and machinery spaces, maintenance of integrity of bulkheads) **Pt 5, Ch 13, Sec 4:** Bilge drainage of machinery space (general, double bottoms, w/o double bottom, additional bilge suctions, separate machinery spaces, emergency bilge drainage, tunnel drainage)	**Pt D, Ch 13, Sec 4:** Scuppers, sanitary discharges, etc (general, size, number, closing arrangement, other discharges) **Pt D, Ch 13, Sec 5:** Bilge and ballast pipings (general, terms, sizes of pipes, pumps, suction arrangement in holds, drainage from deep tanks, fore/after peak tanks, and chain lockers, bilge wells)	No sections in any society for plumbing type components (toilets, sinks, etc). Only major space drainage. In the space category, all societies except NK are organized quite well by space type. DNV and LR have similar breakdowns and information, with these societies providing the most information on arrangements and configuration. ABS has much less information on arrangements and stipulations for configurations. NK is similar to DNV and LR, but with different terminology, using the word bilge over drainage. ABS begins to introduce some concepts seen in LR/DNV drainage sections in the bilge section. When taking all society references in the drainage and bilge sections, there are really no significant differences in the rules, only in the layout of the rules.
529	DRAINAGE & BALLASTING SYSTEM	**Pt 4, Ch 6, Sec 4/7:** Ballast systems (general, pumps, piping and valves, pipes through fuel oil tanks **Pt 4, Ch 6, Sec 4/5:** Bilge System (general, system sizing, system design, pollution prevention, tests)	**Pt 4, Ch 1, Sec 4-I:** Ballast system and drainage of tanks (drainage of ballast tanks, ballast tank filling) **Pt 4, Ch 1, Sec 4-J:** Remotely controlled bilge and ballast system (arrangements, valves, pumps) **Pt 4, Ch 1, Sec 4-H:** Bilge Pumping and piping (general, capacity and type of pumps, pumping arrangement, biulge suction size, pipes through tanks and holds)	**Various throughout Pt 5, Ch 13:** Ship Piping Systems (no dedicated ballast section. Assumed same specification for bilge pipes and pumps are for ballast. Mentions ballast systems in various section all through this Chapter)	**Pt D, Ch 13, Sec 5:** Bilge and ballast pipings (general, terms, sizes of pipes, pumps, suction arrangement in holds, drainage from deep tanks, fore/after peak tanks, and chain lockers, bilge wells)	For drainage systems, see SWBS 528. Items such as pipe and pump sizing are all the same (mechanics based). No significant differences in ballast systems.
530	***FRESH WATER SYSTEMS***					
531	DISTILLING PLANT	No references	No references	No references	No references	No specific rules for distilling plants within rules. Only references to the piping systems
532	COOLING WATER	See SWBS 256 - CIRCULATING & COOLING SEAWATER SYSTEMS				
533	POTABLE WATER	No references	**Pt 5, Ch 13:** Carriage of Potable Water (general, documentation, tests, materials, tank arrangement, piping system, water quality) Compliance with these rules will result in additional notation for potable water carriage	No dedicated section, only reference to fresh water piping and the separation of it from hazardous liquids	No references	DNV has a additional notation available for carriage of potable water (implied that the vessel is a bulk potable water tanker). The other societies do not make references to potable water, only mentioned in the piping section that pipes for fresh water are to be independent and not connected to other piping systems
534	AUXILIARY STEAM SYSTEM - MACHINERY SPACE	Societies do not indicate any specific "auxiliary steam system." All steam system topic are included in SWBS 253 (steam systems)				Reference SWBS 253 for all steam system topics
540	***FUELS AND LUBRICANTS, HANDLING AND STORAGE***					

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
541	SHIP FUEL SYSTEM	See SWBS 260 Group for Ship fluid systems				All topics regarding ship fluid systems can be found in the 260 group of Propulsion
542	AVIATION & GENERAL PURPOSE FUEL SYSTEM	**Pt 4, Ch 6, Sec 7/9:** Helicopter Refueling Systems (storage, arrangement, spill containment, tanks, pumps, piping, fire extinguishing)	**Pt 4, Ch 1, Sec 5-D:** Fuel Oil System, General (no specific aviation fuel rules, requirements)	**Pt 5, Ch 14, Sec 2/2:** Oil Fuel, General Reqts: Special (special flash point fuels receive separate special consideration (e.g. aviation fuel)	No specific section, only general F.O. requirements, but not mention of aviation usage (gen. F.O. systems: Pt D, Ch 13, Sec 9)	ABS is the only society to include a dedicated section on aviation (helicopter) fueling arrangements and F.O. systems, Concluded that others societies would fall under their general fuel oil system requirements
543	AVIATION AND GENERAL PURPOSE LUBE OIL	**Pt 4, Ch 6, Sec 4/15:** LO Storage and Transfer system (storage and transfer systems, fire minimization)	**Pt 4, Ch 1, Sec 5-C:** General Lube Oil System Requirements (filtering, supply, emergency, shut-off arrangement) no specifics for aviation	**No specific rules** for aviation L.O. General L.O. - **Pt 5, Ch 14, Sec 8**: L.O. Systems (general, pumps, alarms, emergency supply, drain tank, filters, maintenance)	No specific section, only general L.O. requirements, but not mention of aviation usage (gen. L.O. systems: Pt D, Ch 13, Sec 10)	Societies do not have special fules for aviation lube oil. Reference general lube oil system for requirements.
544	LIQUID CARGO	IMO regulated, not main class in society rules				Most all aspects of liquid cargoes are governed by IMO and the various library of regulations that guide the carriage of liquids. Such regulatory documents are: International Maritime Dangerous Goods Code (IMDG), Code for Construction and Equipment of Dangerous Chemical Carriers (IBC Code), IGC Code (liquified gas carriers), etc.
545	TANK HEATING	**Pt 4, Ch 6, Sec 4/13.5.7:** FO Heating arrangements in tanks (temperature limits, temperature control, alarms, electric heating, steam heating) **Pt 4, Ch 4, Sec 4/13.7.4:** FO System components - FO heaters (housing, temp controls, relief valves) **Pt 4, Ch 4, Sec 5/3.5.3:** Auxiliary diesels FO heaters (number, capacity)	**Pt 4, Ch 4, Sec 8-F7:** Electric heating equipment - oil heaters (installation, arrangement, tempersature rises, sensors, over-temp safety measures, society acceptasnce upon case basis) **Pt 4, Ch 1, Sec 5-D102:** Machinery Piping - FO heating (temperature limits, sensors, ppies, arrangement)	**Pt 5, Ch 14, Sec 2/6:** Machinery Piping - FO heating arrangements (exhaust drains, monitoring, special cases, pipe material and tests, ele3ctric heating elements) **Pt 5, Ch 14, Sec 2/7:** Temperature Indication (FO) (monitoring oil temperature, warning signs, temp limit controls) **Pt 5, Ch 15, Sec 6:** Cargo heating arrangements for oil tankers (specialized use, but is referenced in general heating - general, blanking arrangements, heating medium, heating circuits, temp indication) **Pt 6, Ch 1, Sec 3/15:** Tank heating control, alarm systems	**Pt D, Ch 13, Sec 9/6:** FO Heaters (temp control, alarms, double bottom tanks, electric heaters, arrangement)	No significant differences. Some societies may address different topics, but the basics are the same.
549	SPECIAL FUEL AND LUBRICANTS, HANDLING AND STOWAGE	No specific topics for special fluids within rules				All topics regarding ship fluid systems can be found in the 260 group of Propulsion. Approval for special arrangements or liquids need to be approved by societies on a basis by basis level.
550	***AIR, GAS AND MISCELLANEOUS FLUID SYSTEMS***					
551	COMPRESSED AIR SYSTEMS - STARTING AIR SYSTEM	**Pt 4, Ch 6, Sec 5/9:** Starting Air System - General (application, requirements, protection, contamination) **Pt 4, Ch 6, Sec 5/9.5:** Air Reservoirs (number, capacity, certification, fixtures, charging)	**Pt 4, Ch 1, Sec 5-J2:** Starting Air Systems (capacity)	**Pt 5, Ch 2, Sec 8/1:** Initial Starting Arrangements (equipment, equipment drivers) **Pt 5, Ch 2, Sec 8/3:** Air Receiver Capacity (capacity w.r.t starts)	**Pt D, Ch 2, Sec 5/3.2:** Starting air Arrangements for Diesels - Reservoirs (number, capacity, capacity based on ship type, propulsion type) **Guidance D2.5.3.1:** Starting Arrangements - Compressed Air (configuration/arrangements)	NK has more stringent rules regard reservoir capacity than the other rules, in respect to single shaft, multiple engine configurations. This will cause for larger reservoirs to be designed. For multi-engine installations, LR will give special consideration. DNV is the same as ABS.

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
551	COMPRESSED AIR SYSTEMS - COMPRESSORS	**Pt 4, Ch 6, Sec 5/9.3:** Air Compressors (number, capacity, protection, tests)	**Pt 4, Ch 2, Sec 10:** Compressors (general, testing, arrangement, layout, design, scantlings, control, monitoring, assembly) Involves mainly the design of the specific compressor **Pt 4, Ch 1, Sec 5-J4:** Emergency Pneumatic Generators (configuration, independence) **Pt 4, Ch 1, Sec 5-J3:** Redundancy (arrangement for compressors with respect to redundancy)	**Pt 5, Ch 2, Sec 8/2:** Air Compressors (number, capacity, time, independence, environment, monitoring, safety valves) **Pt 5, Ch 2, Sec 8/5:** Starting of Emergency Source of Power (emergency generator starting configuration w/ air: stored energy, environment, arrangement)	**Pt D, Ch 13, Sec 13/3:** Number and Capacity of Air Compressors (main propulsion machinery arrgt, compressor drivers, capacity) **Pt D, Ch 13, Sec 13/4:** Emergency Air Compressors (number, configuration, capacity) **Pt D, Ch 13, Sec 13/1**: Arrangement of Air compressors (protection, leakage)	ABS does NOT include emergency configuration here for either main engine starting, or compressor driver emergency configurations. DNV 4-2-10 includes details on the specific design of the compressor machinery and moving parts. No other society goes to this level. But compressors are "off-the-shelf" items to begin with and offer little impact to the designer. The system design will, but not the major compressor machinery
551	COMPRESSED AIR SYSTEMS - PIPING	**Pt 4, Ch 6, Sec 5/9.7:** Starting Air Piping (fitting, joints, pipe runs, air mains)	**Pt 4, Ch 1, Sec 5-I:** Pneumatic Power Supply (pipe runs, valves, pipe configuration, intakes)	No specific rules relating to Compressed Air Piping (safety valves in above entry)	**Pt D, Ch 2, Sec 5/3.1:** Starting air Arrangements for Diesels (starting air main protection configuration) **Pt D, Ch 13, Sec 13/5:** Compressed Air Piping (drainage, pipe runs, independence)	ABS provides more guidance/instruction on piping requirements for compressed air. Rules include joint limitations for different classes, and special considerations for starting air mains when engine bore exceeds a specific amount.
551	COMPRESSED AIR SYSTEMS - PNEUMATIC SYSTEMS	**Pt 4, Ch 7, Sec 7/5:** Pneumatic Systems (application, components, references to 4-6-5/9)	Included in above entries for SWBS 551	Incorporated into above entries for SWBS 551	Incorporated into above entries for SWBS 551	ABS just lists "Pneumatic Systems" as a reference point to designers. It refers them back to the Compressed Air sections.
552	COMPRESSED GASES	NO APPLICABLE RULES FOUND IN ANY CLASS SOCIETY ORGANIZATION				Nothing in main class rules. Rules for special vessels may include paqrts on this topic
553	O2 N2 SYSTEMS	NO APPLICABLE RULES FOUND IN ANY CLASS SOCIETY ORGANIZATION				
554	LP BLOW	NO APPLICABLE RULES FOUND IN ANY CLASS SOCIETY ORGANIZATION				
555	FIRE EXTINGUISHING SYSTEM - OVERALL	**Pt 4, Ch 7:** Fire Safety Systems (general provisions, provisions for specific spaces, fire-extinguishing systems and equipment)	**Pt 4, Ch 6:** Fire Protection, Detection and Extinction (general, pumps, maines, extinguishers, arrangement, foam systems, detection and alarms, fireman outfit, other systems)	**Pt 6, Ch 4, Sec 1/1.4:** Fire Protection, Detection and Extinction for Cargo Ships of less than 500 GT (states that for vessels over 500GT, design is to comply with SOLAS measures and applicable national flag regulations)	**Part R:** Fire Protection, Detection and Extinction (general, construction and arrangement for cargo ships, construction and arrangement for tankers, means of escape, fire detection and extinction, special requirements)	ABS, DNV, and NK all have detailed, in-depth books or sections dedicated to fire syatems. LR simply refers the designer to the applicable IMO/SOLAS reulations. This does not seem to be the most efficient way to handle this matter
555	FIRE EXTINGUISHING SYSTEM - GENERAL	**Pt 4, Ch 7, Sec 1:** General Provisions (application, basic principles, documentation, fire control plan, definitions, piping system references)	**Pt 4, Ch 6, Sec 1:** General Requirements (scope, classification, definitions, documentation)		**Pt R, Ch 1:** General (application, equivalency, defnintions, flag requirements, construction - general)	General top level section references for societies. SOLAS regulations dominate this topic, and hence little difference in the basis of the fire-extinguihsing systems rules
555	FIRE EXTINGUISHING SYSTEM - FIRE PUMPS and H2O DISTRIBUTION SYSTEMS	**Pt 4, Ch 7, Sec 3/1:** Fire Main System (general, fire pumps, main diameter, hydrants, pipes, fire hoses, nozzles, shore connections: mainly SOLAS requirements, with few selected ABS requirements)	**Pt 4, Ch 6, Sec 2:** Fire Pumps and Fire Main (general, fire pumps, main diameter, hydrants, pipes, fire hoses, nozzles, shore connections: mainly SOLAS requirements, with few selected DNV requirements)		**Pt R, Ch 5, Sec 2/1, 2/2, 2.3, 2/4, 2/5, 2/6, 2/19:** Fire pumps, emergency fire pumps, firemain, hydrants and pipes, hoses and nozzles, other pumps, internations connections: mainly SOLAS requirements, with few selected NK requirements)	ABS and DNV quote SOLAS requirements verbatim with proper recogniztion and indication to the degienr that the text is so. NK has verbatim text, but it is not indicated exactly where. Only stated that the ruiles meet the SOLAS requirements. Bottom line ALL socities meet the SOLAs requirements and no significant impact on the designer is brought upon by chagne of society. LR jus refers to SOLAS with no text.
555	FIRE EXTINGUISHING SYSTEM - FIXED GAS FIRE EXTINGUISHING SYSTEMS	**Pt 4, Ch 7, Sec 3/3:** Fixed Gas Fire Extinguishing System (general, CO2 systems, referigerated low-pressure CO2 systems, steam systems, flue gas systems)	**Pt 4, Ch 6, Sec 3:** Fixed Gas Fire Extinguishing Systems (general, carbon dioxide systems, L-P CO2 systems, halogenated hydrocarbon systems, steam systems, other gas systems)		**Pt R, Ch 5, Sec 2/7:** Fixed Gas Fire-extinguishing Systems (general, carbon dioxide systems, steam systems, other gas systems)	ABS and DNV include additional systems in addition to the IMO/SOLAS addressed systems. This includes a Low Pressure CO2 system, where ABS and DNV have almost verbatim wording. DNV includes much more design information/rules for the CO2 system than ABS or NK. This provides more guidance for the designer and less guessing and reliance on other sources

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
555	FIRE EXTINGUISHING SYSTEM - FIXED FOAM FIRE EXTINGUISHING SYSTEMS	**Pt 4, Ch 7, Sec 3/5:** Fixed Foam Systems (high-expansion in machinery spaces, low-expansion foam in machiner spaces, fixed foam outside of machinery spaces)	**Pt 4, Ch 6, Sec 5-B:** Fixed Low Expansion Foam In Machinery Spaces (general) **Pt 4, Ch 6, Sec 5-C:** Fixed High-Expansion Foam in Machinery Spcaes (general, arrangement, capacity, foam generator, generator room)		**Pt R, Ch 5, Sec 2/9:** Fixed Low-expansion Foam in Machinery Spaces (quantity, system, means of control **Pt R, Ch 5, Sec 2/10:** Fixed High-expansion Foam in Machinery Spaces (quantity, system, means of control)	All text and matters regarding fixed foam systems are the same and are verbatim from SOLAS or near repllica of the SOLAS text. There is no impact on the designer in reagrd to a different society from another in this matter. LR again, does not include any text on the matter, only to has reference to SOLAS from the general requirements.
555	FIRE EXTINGUISHING SYSTEM - FIXED PRESSURE WATER-SPRAYING SYSTEMS IN MACHINERY SPACES	**Pt 4, Ch 7, Sec 3/7:** Fixed Pressure Water-spraying System (nozzle type, number and arragnement, subdivision, pressureization, pump capability and location, pump prime mover, clogging precautions)	**Pt 4, Ch 6, Sec 5-D:** Pressure Water-Spraying Systems in Machinery Spaces (general) **Pt 4, Ch 6, Sec 5-E:** Pressure Water-Spraying Systems for Special Category Spaces in Passenger Ships (general)		**Pt R, Ch 5, Sec 2/11:** Fixed Pressure Water-spraying systems in Machinery Spaces (general, nozzles, system,)	All text and matters regarding fixed pressure water-spraying systems are the same and are verbatim from SOLAS or near repllica of the SOLAS text. There is no impact on the designer in reagrd to a different society from another in this matter. LR again, does not include any text on the matter, only to has reference to SOLAS from the general requirements. DNV does include a special section on special category spaces not in the other texts
555	FIRE EXTINGUISHING SYSTEM - AUTOMATIC SPRINKLER, FIRE DETECTION AND FIRE ALARM SYSTEMS	**Pt 4, Ch 7, Sec 3/9:** Automatic Sprinkler, Fire Detection and Fire Alarm System (general, arrangements, characteristics, pressure tank, pumps and piping, location, power sources, firemain connection, testing, spares)	**Pt 4, Ch 6, Sec 8:** Automatic Sprinkler, Fire Detection and Fire Alarm System (application, general, arrangement, capacity, pumps and piping, power sources, testing)		**Pt R, Ch 5, Sec 2/12:** Automatic Sprinkler, Fire Detection and Fire Alarm System (general text)	SOLAS regulates the alarms and such, no significant differences
556	HYDRAULIC FLUID SYSTEM - OVERALL	**Pt 4, Ch 6, Sec 7/3:** Hydraulic Oil Systems (application, tanks, components, requirements)	**Pt 4, Ch 1, Sec 5-H:** Hydraulic Systems (general, power supply, cylinders, accumulator)	No specific rules relating to Hydraulic Oil/Fluid Systems	**Pt D, Ch 13, Sec 10:** Lubricating Oil Systems and Hydraulic Oil Systems (Refers to applicable sections for Fuel Oil Systems, but replacred fuel oil with hydraulic oil)	ABS and DNV are most complete in their guidance to the designer for this topic. ABS offers more complete guidance on fire precautions (none for DNV) and system components such as piping and joints. DNV is more helpful in areas of cylinders and accumulators. LR provides no guidenace at all on this topic. NK provides only basic arrangement related rules for hydraulic oil systems explicity
556	HYDRAULIC FLUID SYSTEM - PIPING	**Pt 4, Ch 6, Sec 7/3.5.1 to 3.5.3:** Hydraulic System Components (pipes, fittings, hoses, valves)	**Pt 4, Ch 1, Sec 5-H1:** General (redundancy, cooling, pumps, valves, pipe, connections, tanks, overflow)	No specific text relating to Hydraulic Oil Fluid Systems in general	**Pt D, Ch 13, Sec 9/1 and 9/5:** See referenced sections from D-13.10.1 (valve, cocks, location, drip trays, drainage arrangements)	ABS provides the most in-dept analysis in the hydraulic oil section of the rules on this matter, NK anmd DNV only talk to arrangement related rules, no specific calculation or strength related items.
556	HYDRAULIC FLUID SYSTEM - ARRANGEMENT	**Pt 4, Ch 6, Sec 7/3.3:** Hydraulic Oil Storage Tanks (location, vent terminations)	**Pt 4, Ch 1, Sec 5-H1:** General (includes necessary arrangements for components and system in general)	No specific text relating to Hydraulic Oil Fluid Systems in general	**Pt D, Ch 13, Sec 9/1**: General (location and arrangement)	In terms of designer guidance, DNV provides the most complete picture for arrangements of the system. ABS is general and provides only one defined rule for stoprage tank locatgion. DNV includes more location/arrangement topics and saefty features
556	HYDRAULIC FLUID SYSTEM - CYLINDERS	**Pt 4, Ch 6, Sec 7/3.5.5:** Hydraulic System Components - Hydraulic Power Cylinder (acceptable recognized standard for fluid power cylinders, non-recognized std designed cylinders to follow applicable rules in "pressure vessel" section)	**Pt 4, Ch 1, Sec 5-H3:** Hydraulic System Cylinders (loading, safety factors, buckling, scantlings)	No specific text in relation to Hydraulic Oil Cylinders	No specific text in relation to Hydraulic Oil Cylinders	In terms of guidance for the designer, DNV provides the most complete picture for the design of the cylinder. ABS slides responsibility to a recognized standard design. NK and LR have no specific mention of this topic.
556	HYDRAULIC FLUID SYSTEM - ACCUMULATORS	**Pt 4, Ch 6, Sec 7/3.5.4:** Hydraulic System Components - Accumulators (reference to Pressure Vessel section for design requirements, location, components)	**Pt 4, Ch 1, Sec 5-H4:** Hydraulic System Accumulators (requirement to conform with 4-1-3 for pressure vessels, arrangement, safety, marking, coatings)	No specific text in relation to Hydraulic Oil Accumulators. But inferred that accumulators must conform to requirements in Pt 5, Ch 11 "Other Pressure Vessels"	No specific text in relation to Hydraulic Oil Accumulators.	ABS and DNV asre the only one to have rtext relating to accumulators. LR does refer to the pressure vessel section in another section. Hence, all three are dependent upon their requirements for pressure vessels. NK does no explicity state this, but one might infer it under common knowledge on accumulators. With this uniformity, the impact on the designer is minimal
557	LIQUID GASES, CARGO	**Pt 5, Ch 8:** Vessels Intended to Carry Liquefied Gases in Bulk (additional notation, not in main class)	**Pt 5, Ch 5:** Liquefied Gas Carriers (special notation, not main class)	**Pt 5, Ch 8:** Vessels Intended to Carry Liquefied Gases in Bulk	**Pt N:** Ships carrying liquefied gases in bulk (additional notation, not main class)	For liquid and/or gas cargo vessels, special rules and notations are in place for each society. The IMO is heavily involved in these vessels and their safety. Many topics in relation to the carriage or the actual cargo and the cargo-related systems are IMO regulated.

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
558	SPECIAL PIPING SYSTEMS	NO SPECIFIC DESIGNATED CLASSIFICATION SOCIETY RULES OR SYSTEMS				Special piping systems can be designated as those for gas carriers, oil carriers, and the like. Not part of main class rules.
560	***SHIP CONTROL SYSTEMS***					
561	STEERING CONTROL SYSTEMS	n/a	n/a	n/a	n/a	
562	RUDDERS - GENERAL	**Pt 3, Ch 2, Sec 14:** Rudders (general, rudder force, rudder torque, stocks, couplings, pintles, double plated, single plated)	**Pt 3, Ch 3, Sec 2-F:** Rudders (arrangements, details, plating, bending, web plates, single plated, mounting)	**Pt 3, Ch 13, Sec 2:** Rudders (stock and main bearing, double plated, single plated, couplings, pintles, ancillary items)	**Pt C, Ch 3:** Rudders (general, force, torque, strength calculations, rudder stocks, plates, frames, couplings, pintles, bearings, accessories)	DNV only allows double plated rudders, with single plated only allowable for small, specialized, restricted vessels. The other societies do not state any such stipulation. Calculations in clude stipulations for items such as cutout rudders and attach,ment arrangements
562	RUDDERS - DESIGN FORCES	**Pt 3, Ch 2, Sec 14/3:** Design Rudder Force (used for scantling calcs - rudders without cutouts has 6 variables in the equation) **Pt 3, Ch 2, Sec 14/5:** Design Rudder Torque for Sacantlings (ahead and astern calculations)	**Pt 3, Ch 3, Sec 2-D:** Design Loads and Stress Analysis (rudder force for scantlings, rudder torque, stress analysis)	**Pt 3, Ch 3, Sec 2/2:** Rudder Construction - Double Plated (forces built into scantling equation)	**Pt C, Ch 2, Sec 2:** Rudder Force (used for scantling calcs - 6 variables)	All equations for the design rudder force are the same, except for LR. Although slight differences exist in the format of the equatrion and the layout, the end result will be very close. However, LR has a much more involved process to determine rudder scantlings for double plate rudders. In LR, the rudder scantlings are dependent in part by the rudder stock diameter, which includes variables such as pintyle arrangements, and pressure centers. The other 3 societies are much more basic and easily followed.
563	HOVERING AND DEPTH CONTROL (SUBMARINE)	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION / DESIGN				
564	TRIM SYSTEM (SUBMARINES)	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION / DESIGN				
565	TRIM AND HEEL SYSTEMS	no applicable section	no applicable section	no applicable section	no applicable section	
566	DIVING PLANES AND STABILIZING FINS (SUBMARINES)	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION / DESIGN				
567	STRUT AND FOIL SYSTEMS	NOT APPLICABLE TO MAIN CLASS COMMERCIAL SURFACE SHIP CONSTRUCTION / DESIGN				Some societies get in to foil systems in the special craft or high sleed and light craft series of their rules, but no mention in main class rules
570	***UNDERWAY REPLENISHMENT SYSTEMS***	THE BELOW ENTRIES MAY BE RELATED TO GENERAL SYSTEMS, NOT NECESSARILY THE "UNDERWAY REPLENNISHMENT" UMBRELLA (i.e cargo handling equipment can I nclude container cranes, or general shipboard cranes)				
571	REPLENISHMENT AT SEA SYSTEMS	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION / DESIGN				
572	STORES HANDLING SYSTEMS	SEE SWBS 572 FOR ALL MATERIAL HANDLING EQUIPMENT AND RULES				
573	CARGO HANDLING SYSTEMS	**Pt 6, Ch 6, Sec 4:** Cargo Handling Equipment (for reefer cargo ships)	N/A	**Pt 5, Ch 15, Sec 3:** Cargo Handling Systems for Oil Tankers (general, cargo pumps, cargo piping system, terminal fittings, bow/stern loading and discharge arrangements, cargo tank connections, remote control valves, cargo handling controls) **Also see auxiliary** rules for lifting equipment for cranes and the like.	See Rules for Cargo Handling Systems (not included in the main class rules/guides)	Auxiliary rules / rulebooks here, not in main class.
575	VEHICLE HANDLING AND STOWAGE SYSTEMS	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES for MAIN CLASS				
580	***MECHANICAL HANDLING SYSTEMS***					
581	ANCHOR HANDLING & STOWAGE SYSTEM - ANCHORS MATERIALS	**Pt 2, Ch 2, Sec 1:** Materials for Equipment - Anchors (manufacture, annealing, testing, inspection, test details, markings)	**Pt 3, Ch 3, Sec 3/D2:** Anchor Materials (must comply with applicable material rules from Pt 2, lists general approved material types) See below entry for more topics	**Pt 2, Ch 10, Sec 1:** Equipment for Mooring and Anchoring - Anchors (scope, manufacture, cast steel, forged steel, fabricated steel, test, identification, certification)	**Pt L, Ch 2:** Anchors (application, types, materials, manufacture, arm length, mass, tests, marking, painting)	ABS states only stockless anchors are to be considered. The others discuss stockless and stocked . The testing and procedures are the same, as are the standards. ABS has focused section on annealing of material, others don't.
581	ANCHOR HANDLING & STOWAGE SYSTEM - ANCHORS	**Pt 3, Ch 5, Sec 1:** Anchoring, Mooring, and Towing Equipment (general, equipment weight and sizing, tests, types, high strength considerations)	**Pt 3, Ch 3, Sec 3/A to Sec 3/D:** Anchoring (general, materials, shackle, testing, identification, equipment specification, stocked and high holding considerations)	**Pt 3, Ch 13, Sec 7/1 to Sec 7/3:** Ship Control Systems - Equipment: Anchors (general, equipment requirements, high holding power anchors, stocked anchor considerations)	**Pt C, Ch 27, Sec 1:** Anchors, Chain Cables, and Ropes (general, equipment numbers, stocked anchor considerations, high holding)	ABS does not discuss stocked anchors. All use equipment number (same equation) and identical equipment charts for sizing anchors. DNV and LR have equipment reduction considerations for restricted service vessels.

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
581	ANCHOR HANDLING & STOWAGE SYSTEM - ANCHOR CHAIN MATERIALS	**Pt 2, Ch 2, Sec 2:** Materials for Equipment - Anchor Chain (scope, general, dimensions, tolerances, material, testing, chain lengths, chain length tests, markings, accessories, unstudded shirt-link)	**Pt 3, Ch 3, Sec 3/E2:** Anchor Chain Cables - Materials (type, certification, steel type, notation) **Pt 3, Ch 3, Sec 3/E3:** Anchor Chain Cables - Heat treatment and material testing (tests and treatments)	**Pt 2, Ch 10, Sec 2:** Equipment for Mooring and Anchoring - Stud Link Chain Cables (scope, manufacture, cast, butt welded, forged, material, welding, heat treatment, testing, dimensions, tolerances, identification, certification)	**Pt L, Ch 3:** Chains (application, types, materials, manufacture, heat treatment, dimensions, tolerances, mass, tests, marking, painting)	The different parts/sections are combined into one comment entry due to the fact that they all cover the same material, but in different formats. All societies use same equipment number / equipment tabular weight/dimension scheme for sizing. Also, all testing and testing criteria are the same for all societies. No significant difference between societies when it is all said and done.
581	ANCHOR HANDLING & STOWAGE SYSTEM - ANCHOR CHAINS	**Pt 3, Ch 5, Sec 1/1 and 1/3:** Anchoring, Mooring, and Towing Equipment (general, equipment weight and sizing) this used equipment number and tables like anchor sizing	**Pt 3, Ch 3, Sec 3/E:** Anchor Chain Cables (general, material - see above entry, chain tests, tolerances, identification, repair)	**Pt 3, Ch 13, Sec 7/4:** Ship Control Systems - Equipment: Chain Cables (material/anchor type restriction, material allowed, equipment number, tabular equipment characteristics)	**Pt C, Ch 27, Sec 1:** Chain Cables (reference to Pt L of rules. States a limitation of material type with anchor type, also includes equipment number and applicable chain characteristics)	
581	ANCHOR HANDLING & STOWAGE SYSTEM - CHAIN LOCKERS	No specific rules found. Only statements that anchor chain storage and design needs to be sufficient and appropriate.	**Pt 3, Ch 3, Sec 3/B104:** Structural Arrgt for Anchoring Equipment - Chain Locker (arrangement, configuration, strength, drainage)	**Pt 3, Ch 13, Sec 7/8:** Structural Requirements - Chain Lockers (size, configuration, strength, securing)	No specific rule	DNV and LR have specific rules regarding the securing the inboard ends of the anchor chain, which involve specific numbers for allowed force and design loads
581	ANCHOR HANDLING & STOWAGE SYSTEM - ANCHOR HAWSE PIPE	**Pt 3, Ch 5, Sec 1/13:** Anchoring, Mooring and Towing Equipment - Hawse Pipes (sizing, welding, H2O pressure testing for watertightness)	**Pt 3, Ch 3, Sec 3/B101:** Structural Arrgt For Anchoring Equipment - Hawse Pipe (size, curvature)	**Pt 3, Ch 13, Sec 7/8.3:** Structural Requirements - Hawse Pipes (size, scantlings, configuration)	No specific rule	ABS, DNV, and LR all has general the same rules for hawse pipes. Designs must be adequate for the usage and service of the vessel. ABS does specify watertight testing to a specific pressure. Mostly, "common sense" engineering practice is applied.
581	ANCHOR HANDLING & STOWAGE SYSTEM - ANCHOR WINDLASS	**Pt 3, Ch 5, Sec 1/11:** Windlass or Winch (general, support structure) **Pt 4, Ch 5, Sec 1:** Anchor Windlass (general, materials, design, inspection, testing) Recognizes applicable ISO, SNAME, JIS, and BS MA standards for windlasses	**Pt 3, Ch 3, Sec 3-F:** Windlass and Chain Stoppers (general, design, materials, testing)	**Pt 3, Ch 13, Sec 7/6:** Windlass design and testing (power reqts, pull, testing, performance, arrangement)	**Pt D, Ch 16, Sec 2:** Windlasses (documentation, performance, tests)	Windlasses are mainly off the shelf equipment for commercial design. LR has an additional equation for the short term pull power for anchor breakout pull that ABS/DNV/NK does not have. All other aspects are the same.
582	MOORING & TOWING SYSTEMS - TOWLINES / MOORING LINES	**Pt 4, Ch 5, Sec 1/9:** Hawsers and Towlines (guidance, suggestions, general). Tables of line number, length, and breaking load based on equipment #	**Pt 3, Ch 3, Sec 3-G:** Towlines and Mooring Lines (general, materials, testing). Tables of line number, length, and breaking load based on equipment #	**Pt 3, Ch 13, Sec 7/5:** Towlines and Mooring Lines (arrangement, general, strength). Tables of line number, length, and breaking load based on equipment #	**Pt L, Ch 4:** Steel Wire Ropes (application, grades, manufacture, mass, tests,) **Pt L, Ch 5:** Fibre Ropes (application, manufacture, materials, diameter, tests) **Pt C, Ch 27 Sec 1/5 and Sec 1/6:** Mooring Lines and towlines (number, strength). Tables of line number, length, and breaking load based on equipment #	ABS, DNV, and LR all state that mooring and towing lines are not a part of classification. But they all provide information/guidance on the recommended number/strength of these lines. NK has REQUIREMENTS for mooring lines, but not towlines. All information based on equipment number and all have identical tables and results, but NK is required for mooring
583	BOATS, BOAT HANDLING & STOWAGE SYSTEM - LIFEBOATS	No rules listed in ABS books regarding lifeboats.	**Pt 3, Ch 6, Sec 3-A:** Survival Craft and Rescue Boats (all text from SOLAS and IMO documents)	No rules listed in LR books regarding lifeboats.	No rules listed in NK regarding lifeboats	All matters regarding lifeboats and lifesaving are found. This issue is addressed in IMO Regulations, Resolutions, SOLAS, and USCG CFR documentation. DNV is the only one to quote IMO/SOLAS text in their rulebook
583	BOATS, BOAT HANDLING & STOWAGE SYSTEM - DAVITS - CONSTRUCTION OF EQUIPMENT	No specific rules in SVR2000. For boats, if applicable, see ABS Rules for Steel Vessels Under 90 meters, or ABS Rules for Reinforced Plastic Vessels for boat related rules	For construction of such boats, see Rules for Certification and Classification of Boats, or Rules for Vessels under 90 meters.	**LR Provisional Rules** - Launch and Recovery Appliances for Survival Craft and Rescue Boats (LRDAVIT) For boats, see applicable rules for boats or vessels under 90 meters	See Rules for Vessels Under 90 meters or Rules for Fiberglass Vessels.	Items such as lifeboats and auxiliary smal craft are most often off-the-shelf supplied equipment, and do not directly impact the ship designer, except for the space, weight, andf arrangement configurations which still must be addrssed during general arrangements and weights.

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
583	BOATS, BOAT HANDLING & STOWAGE SYSTEM - DAVITS - CONFIGURATION	No reference to this topic in the Rules	**Pt 3, Ch 1, All Sections:** This chapter is entitled Life Saving Applicances and Arrangements. This is direct text from applicable IMO sources (SOLAS, MSC, etc) relating to the required saefty topics for ships.	No reference to this topic in the Rules	No reference to this topic in the Rules	DNV provides the easiest tool for the designer in that it includes the applicable rules within their Rules text for reference. The other socities depend on the designer to have knowledge of the applicable regulations and go find the text themselves, which may be time consuming and not cost-effective. But it is an important topic to the designer in relation that the arrangement required must be designed into the ship
584	LANDING CRAFT HANDLING AND STOWAGE SYSTEMS	NO SECTIONS FOUND IN SOCIETY RULES - LANDING CRAFT NOT APPLICABLE TO COMMERCIAL SHIPS				
585	ELEVATING AND RETRACTING GEAR	Nothing in main class rules. ABS does have a guide for **Shipboard Elevators**, as well as **Certification of Cranes** that may provide information pertaining to this topic (publications not in possession)	Not in main class rules (except for mention that strength must be sufficient for cargo lifets and ramps). DNV does have other publications (not included with main rules) that address this topis such as: **Rules for Lifts** and **Rules for Lifting Appliances**	No in main class rules. See **Lloyds Registers Code for Lifting Appliances in a Marine Environment** for information on elevators and ramps	Nothing in main class rules. NK does have a **Rules for Cargo Handling Appliances** guide for additional systems that includes lifts and the like.	Due to the fact of insufficent information, a direct comparison cannot be made regarding this topic. All societies do have auxiliary books for lifts (elevators) and lifting appliances (cranes, etc). It is recommened to consult these additional texts before proceding on this topic area.
586	AIRCRAFT RECOVERY SUPPORT SYSTEM	NO SECTIONS FOUND IN SOCIETY RULES - ALL HELICOPTER RELATED ITEMS IN SWBS 587				
587	AIRCRAFT LAUNCH SUPPORT SYSTEMS	**Pt 3, Ch 2, Sec 11:** Hull Construction - Helicopter Decks (general, structure, material, safety)	**Pt 6, Ch 1, Sec 2:** Helicopter Decks (general, design loads, strength requirements, ship safety reqts, helo safety reqts)	**Pt 3, Ch 9, Sec 5:** Ship Structures - Helicopter Landing Areas (general, arrangements, scantlings, stiffening)	No applicable section	No specific rules for aircraft support systems, only structural elements to flight operations. ABS determines scantling upon loading conditions identified in the rules, but no specific equation calculations. LR includes loading cases and scantling direct calculation equations. DNV is most complete. DNV includes markings, safety considerations, and direct scantling equations. Also has the most variables/inputs to its calcs.
588	AIRCRAFT HANDLING SERVICE & STOWAGE	NO SECTIONS FOUND IN SOCIETY RULES - ALL HELICOPTER RELATED ITEMS IN SWBS 587				
589	MISCELLANEOUS MECHANICAL HANDLING SYSTEM	NOT IN CLASSIFICATION SOCIETY MAIN CLASS RULES				These such appliances are not main class topics, but rather fall under additional rules and notation books. For example, elevators, cranes, lifting appliances, etc.
590	***SPECIAL PURPOSE SYSTEMS***					
591	SCIENTIFIC AND OCEAN ENGINEERING SYSTEMS	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION / DESIGN				
592	SWIMMER AND DIVER SUPPORT AND PROTECTION SYSTEMS	No specific text in main class rules. May be some information in Rules for Underwaqter Vehicles, Systems and Hyperbaric Facilities, and the Crane certification publication relating to this, but cannot be certain	**Pt 6, Ch 1, Sec 4: Diving Systems** (general, position keeping, electrical systems, fire safety, sanitary systems, testting, stability)	Some material in the LR Code for Lifting Appliances in a Marine Environment (publication not in BIW possession)	Rules for Diving Systems (includes surveys, diving bells, deck decompression chambers, handling and mating systems, gas supply, instruments, communication systems, emergency curfacing, piping, electrical) More slanted toward individual diving systems, not surface ship support systems and rules	Societies do not address this topic in general rules. But they do discuss this topic in auxiliary rules and books to the main class rules. This supplemental rules include cranes and lifting appliance books. DNV has a dedoicated notation for Diving Support Vessel which includes a lot of information and rules on this topic.
593	ENVIRONMENTAL POLLUTION CONTAINMENT SYSTEMS	**Pt 4, Ch 6, Sec 4/5.7:** Bilge System Oil Pollution Preventions Measures (general, oily water sewparation/filtering, sludge tank, sludge pumping and piping) Includes reference to applicable MARPOL regulations that must be met . Includes PPM limits, tank sizes, etc)	**Pt 4, Ch 1, Sec 4-M:** Oil Pollution Prevention (application, tanks arrangement, tank capacity, discgarge cinncetion flanges, ppm limits) Includes MARPOL references **Pt 6, Ch 12**: Environment Class (DNV special notation for special consideration to emmissions and dishcharges, and pollutant liquid tank arrangement)	**Arrangements and Equipment for Environmental Protection** (separate LR publication, not part of main rules) Not in BIW possession	**Rules for Marine Pollution Prevention Systems** (separate NK publication, not part of main rules, although required for general class) Includes: survey information, construction and equipment for prevention of oil pollution, shipboard pollution plans, noxious discharge prevention	DNV has a special notation, that includes much more in-depth environmental concerns and rules than the other basic main class rules. ClassNK auxiliary rule book is very in-depth and concise. Include MARPOL references. In general, pollution and environment concerns are regulated by IMO sources. Societies rarely require above and beyond these regulations, except in some cases of special CLEAN notations like that of DNV. Due to MARPOL and IMO governing many related topic, there are little significant differences between societies in terms of environmental pollution aspects.
594	SUBMARINE RESCUE, SALVAGE, AND SURVIVAL SYSTEMS	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION / DESIGN				

	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
595	TOWING, LAUNCHING & HANDLING UNDERWATER SYSTEMS	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION / DESIGN				
596	HANDLING SYSTEM FOR DIVER AND SUBMERSIBLE VEHICLES	NOT APPLICABLE TO COMMERCIAL SURFACE SHIP CONSTRUCTION / DESIGN				Societies do not address this topic in general rules. But they do discuss this topic in auxiliary rules and books to the main class rules. This supplemental rules include cranes and lifting appliance books
597	SALVAGE SUPPORT SYSTEMS	NOT COVERED IN MAIN CLASS SOCIETY RULES				
598	AUXILIARY SYSTEM OPERATING FLUIDS	See comments for notes				All rules regarding operating fluids (fuel oil, lube oil, hydraulic oil) is contained in SWBS 556 (hydraulic system) or in SWBS 260 series group (machinery operating fluids)
599	AUXILIARY SYSTEMS REPAIR PARTS & TOOLS	**Pt 4, Ch 2, Sec 1: Appendix 2 -** Spare Parts (propulsion engines and auxiliary engines (diesels)	**Pt 4, Ch 1, Sec 8:** recommended spare parts only	**Pt 5, Ch 16:** suggestions for spare parts only	**Pt D, Ch 21:** Spare Parts, Tools and Instruments (large portion meant for guidance only, and related to SWBS200, but some info on pumps and aux. Systems	All societies mention that spare parts are highly governed by flag country, but all offer suggestions and acceptance upon appropriate spare parts. The spare parts listed in the texts are VERY similar in content with respect to equipment and number.

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
600	***OUTFIT AND FURNISHINGS, GENERAL***					
601	GENERAL ARRANGEMENTS - OUTFIT AND FURNISHINGS DRAWINGS	N/A	N/A	N/A	N/A	
602	HULL DESIGNATION AND MARKING	International Conference on Load Lines Regulated (IMO)				
603	DRAFT MARKS	N/A	**Pt 3, Ch 4, Sec 2-C:** Draught Marks (general - scale indication)	N/A	N/A	DNV includes a section on requiring the scale of the draft marks to be indicated on the hull. The other societies do not have any reference to draft marks/markings.
604	LOCKS, KEYS, AND TAGS	N/A	N/A	N/A	N/A	
605	RODENT AND VERMIN PROOFING	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				Regulations are in place to say that ships are to be rodent free at delivery
610	***SHIP FITTINGS***					
611	HULL FITTINGS	N/A	N/A	**Pt 3, Ch 10, Sec 5/5:** Fittings and attachments, general (weld quality, examination, testing) **Pt 3, Ch 10, Sec 5/7:** Other fittings and attachments (gutterway bars, minor attachments, arrangements)	N/A	There are not specific sections on hull fittings, except for LR. It is assumed that all such fittings be designed and constructed with modern, sound engineering backgrounds with approved materials and techniques. The LR rules only address these such topics anyhow, and not necessarily the actual fitting.
612	RAIL STANCHIONS & LIFELINES	**Pt 3, Ch 2, Sec 17/1:** Bulwarks and Guard Rails (height, strength, spacing - all set distances, no equations)	**Pt 3, Ch 1, Sec 10-E:** Protection of Crew (ICLL Regulation, regulation interpretations) ICLL Regulations includes guard rail height, spacing, arrangement)	**Pt 3, Ch 8, Sec 5/1:** Bulwarks and Other Means for the Protection of Crew - General Requirements (height, spacing, arrangement)	**Pt C, Ch 23, Sec 1:** Bulwarks and guardrails (general, dimensions, construction, miscellaneous)	The dimensions (height, spacing, and general arrangement) of these items are regulated by ICLL, although DNV is the only one that gives direct reference to the ICLL. Hence, all societies have the same requirements for this topic and no significant differences. DNV does provide more in-depth coverage on the topic of crew protection than the others
613	RIGGING AND CANVAS	No applicable section found in main class rules	**Pt 3, Ch 3, Pt 4:** Masts and Rigging - (materials, welding, arrangement, design, scantlings)	**LR Code for Lifting Appliances in a Marine Environment** (publication not acquired): contains pertinent information in relation to riggings and masts for ships. **Pt 3, Ch 9, Sec 10**: Lifting appliances and support arrangements (general, masts, derrick posts, crane pedestals, lifting appliances) References "LAME" publication listed above	**Pt C, Ch 26:** Masts and Derrick Posts (general, masts without cargo gear, derrick posts, mast diameter, plate thickness) **References another** publication for Construction of Cargo Handling Appliances for more detail on these items relating to cargo handling	ABS has no section in the main class text relating to this topic. NK's section only refers to masts in which no cargo derricks are equipped. LR and DNV are in part the cargo derricks and masts. It depends on the use of the mast/post to determine the best society or differences in the societies. All societies have a cargo handling/lifting appliance special notation section which would be applicable for such instances, but it is not analyzed here.
620	***HULL COMPARTMENTATION***					
621	NON-STRUCTURAL BULKHEADS	NO APPLICABLE RULES FOUND IN ANY CLASS SOCIETY ORGANIZATION				
622	FLOOR PLATES & GRATINGS	For Scantlings of floor plates, see SWBS 13x, 14x, or 15x as applicable	For Scantlings of floor plates, see SWBS 13x, 14x, or 15x as applicable	For Scantlings of floor plates, see SWBS 13x, 14x, or 15x as applicable	For Scantlings of floor plates, see SWBS 13x, 14x, or 15x as applicable	
623	LADDERS	NO APPLICABLE RULES FOUND IN ANY CLASS SOCIETY ORGANIZATION				
624	NON-STRUCTURAL CLOSURES	NO APPLICABLE RULES FOUND IN ANY CLASS SOCIETY ORGANIZATION				
625	AIRPORTS, FIXED PORTLIGHTS, AND WINDOWS (SIDE SCUTTLES)	**Pt 3, Ch 6, Sec 1/3:** Navigation - Visibility, Windows and their arrangements (framing, inclination angle, glass type, view, edges) **Pt 3, Ch 2, Sec 17/7:** Portlights (application, location, construction)	**Pt 3, Ch 1, Sec 11-L:** Side Scuttles (ICLL regulation, ICLL interpretations, arrangements, glass dimensions)	**Pt 3, Ch 11, Sec 6/5:** Side Scuttles, Windows and Skylights (location, arrangement, toughened safety glass, frames) **Pt 7, Ch 9, Sec 2/4:** Bridge/Wheelhouse Windows (construction, angles, edges, heights, view) For one Man Watch notation	**Pt C, Ch 23, Sec 5:** Side Scuttles (arrangement, application, protection) **Pt W, Ch 2:** Navigation Bridge Visibility (bridge window configuration, field of vision, type)	ABS requirements for bridge/wheelhouse windows (those the same as the LR rules in Pt 7) are required, whereas the LR Pt 7 rules are only for One Man Watch notation. ABS is for main class notation, but the rule content is essentially the same.
630	***PRESERVATIVES AND COVERINGS***					Not a main aspect of classification society rules. All state that steel must be protective. Many society have approved coatings in their inventory lists of approved products which can be used. Most major marine paint suppliers has the proper approval or coatings for all uses.

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
631	PAINTING (COATINGS)	**General** - (all steel to be painted/coated, possible scantling reduction with approved coatings/protection)	**Pt 3, Ch 1, Sec 18:** Corrosion Prevention (general, corrosion prevention systems - general, coatings) Basically states that all steel must be coated with exceptions	**Pt 3, Ch 2, Sec 3/2:** Prefabrication primers (primer composition, tests on primer/weld interaction,) **Pt 3, Ch 2, Sec 3/6**: Corrosion protection coatings for SW ballast spaces (color, must be coated) **Reference to LR** List of Paints, Resins, Reinforcements, and Associated Materials	**Pt C, Ch 25, Sec 2:** Painting (steel work must be protected, surface preparation) mention of using only "suitable" paint Guidance C25: Cements and Painting (paint type restrictions, coated areas for special vessels, I.e. bulk carriers, situation for paint alternatives)	LR has dedicated publication to Paints and the like. In general, all societies state that steel must be effectively y coated with approved or suitable paint/coatings. No significant differences. There are SOLAS regulations pertaining to coating specifications
632	ZINC COATING	**Pt 3, Ch 2, Sec 18/5.3:** Salt Water Ballast Space (references zinc coatings as an example to protect steel from salt water ballast.) No other references to zinc coatings	**Pt 3, Ch 1, Sec 18:** Corrosion Prevention (only mention in passing that zinc based coatings are known as "hard coatings", and referenced "hard coatings" in a SOLAS requirement for SW ballast tanks, same as ABS)	**Pt 2, Ch 10, Sec 6/4:** Steel wire ropes - Zinc coating tests (density of coating, uniformity, adhesion test) References to use recognized Standard for these tests	No applicable rule found	This topic is not clearly covered in-dept by any society. ABS only references zinc coatings as an example of what might be used in coating a SW ballast tank, same as DNV (which is a SOLAS requirement - SW ballast coating). LR only talks to it in reference to steel wire rope coating and the testing of the coating. NK has no reference to zinc coatings in its main text.
633	CATHODIC PROTECTION - GENERAL	No applicable rules found	**Pt 3, Ch 1, Sec 18-B3:** Cathodic Protection (general, securing)	**Pt 3, Ch 2, Sec 3/3:** Internal Cathodic Protection (arrangement, securing)	No applicable rule found	ABS has no section on cathodic protection/anodes. DNV and LR are very similar. LR is more specific in terms of securing/attachment arrgt than DNV, which offers more guidance for the designer.
633	CATHODIC PROTECTION - ANODES	No applicable rules found	**Pt 3, Ch 1, Sec 18-B3:** Cathodic Protection (location, applicability)	**Pt 3, Ch 2, Sec 3/4:** Aluminum and Magnesium Anodes (applicability, allowable potential energy, location)	No applicable rule found	ABS has no section on cathodic protection/anodes. LR offers more specifics than DNV.
634	DECK COVERING	**Pt 3, Ch 2, Sec 3/9:** Deck Covering Compositions (materials, resistance, surface preparation, holdfast spacing)	No dedicated to deck covering found in main text, as ion other societies.	**Pt 3, Ch 2, Sec 4:** Materials - Deck Covering (general - scantling reduction, corrosion prevention, securing, ignition feasibility)	**Pt C, Ch 17, Sec 4:** Deck Compositions (general - composition, installation, insulation) **Pt R, Ch 2, Sec 7/1.3:** Combustible Materials (space/ignition feasibility considerations)	ABS is the only society to state minimum fastener spacing for deck covering. ABS makes no reference to scantling reduction possibilities due to addition of deck covering. NO similar references could be found in DNV, although it may be "hidden" within the body of another section, and overlooked. The other three do address basically the same things such as materials and fire safety considerations
635	HULL INSULATION	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				Assumed that all insulation and insulation plans must be approved by the society, but no specific text in relation to hull insulation.
636	HULL DAMPING	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				Hull damping for acoustic and wake signatures not applicable to commercial vessels. All damping measures are in terms of vibration damping from machinery, addressed in applicable machinery sections
637	SHEATHING	**Pt 3, Ch 2, Sec 12/5.1:** Tunnels (sheathing for crown plating in way of hatches in tunnels) includes minimum scantling for wood sheathing	No reference found to structural sheathing found in main class rules.	**Addressed in 634** - Deck Covering (only reference is to securing of sheathing to the deck)	No reference found to structural sheathing found in main class rules.	Most all sheathing references in society rules are in relation to cables (addressed in Electrical section - 300). Or piping sheathing. ABS does have small reference to tunnels and the crown plating in way of hatches, which includes a minimum for the wood sheathing scantling.
638	REFRIGERATED SPACES	**Pt 6, Ch 2, Sec 5:** Carriage of Refrigerated Cargoes - Refrigerated Cargo Spaces (general, design considerations, insulation, stowage and side shoring, air circulation, ventilation, ducts, gratings, spar decks, bilge and drainage arrangements, pipes, tests and inspections)	**Pt 5, Ch 10, Sec 4:** Carriage of Refrigerated Cargoes - Refrigerated Chambers, Construction, Insulation, and Instrumentation (arrangement and design, insulation construction, moisture protection, air circulation system, pipes, temperature measurement, indication equipment)	**Pt 6, Ch 3, Sec 9:** Refrigerated Cargo Spaces - Refrigerated Cargo Spaces (airtightness, insulation, access plugs and panels, air circulation and distribution, air refreshing) **Pt 3, Ch 2, Sec 2/2:** Fracture Control - Refrigerated spaces (temperature and grade relationship, deck temperature assessment)	**Rules for Cargo Refrigeration Systems, Ch 5:** Refrigerated Chambers (construction, insulation, temperature measuring, drainage) **Rules for Cargo Refrigerating Systems, Ch 3, Sec 4:** Other Arrangements in Refrigerated Chambers (defrosting, ventilation)	All of these sections and requirements pertain to special notation in addition to the main classification. All of these rules relate to vessels with additional notation to carry refrigerated cargoes in dedicated cargo areas. For these cases, rules are not significantly different.
639	RADIATION SHIELDING	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
640	***LIVING SPACES***					
641	OFFICER BERTH/MESS FURNISHING	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				

SWBS	Description	ABS (Baseline)	DNV	LR	CLASS NK	Significant Difference
642	NON-COMMISSIONED OFFICER BERTH/MESS FURNISHING	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
643	ENLISTED BERTH/MESS FURNISHING & MESSING SPACES	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
644	SANITARY SPACES & FIXTURES	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
645	LEISURE & COMMUNITY SPACES	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
650	***SERVICE SPACES***					
651	COMMISSARY SPACES	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
652	MEDICAL SPACES	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
653	DENTAL SPACES	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
654	UTILITY SPACES	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
655	LAUNDRY SPACES	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
656	TRASH DISPOSAL SPACES	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
660	***WORKING SPACES***					
661	OFFICES	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
662	MACHINERY CONTROL CENTERS FURNISHINGS	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
663	ELECTRIC CONTROL CENTERS FURNISHINGS	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
664	DAMAGE CONTROL STATIONS	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES - see comments				No specific texts on damage control stations other then electrical equipment location and placement. SOLAS does have regulation pertaining to indicates, displays and the like in relation to this topic.
665	WORKSHOPS LABS - TOOLS & EQUIPMENT	No classification society rules for tools and equipment for workshops or labs				
670	***STOWAGE SPACES***					Stowage space not for cargo-carrying is not within the main scope of the classification society rules. Good engineering practice dictates design of these spaces for the most part
671	LOCKERS & SPECIAL STOWAGE	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				General stowage and lockers are not regulated specifically by class society rules.
671	PAINT LOCKERS	**Pt 4, Ch 7, Sec 2/5.1:** Fire Safety Systems for Paint Lockers (fire extinguishing protection for different sized paint lockers)	No dedicated sections for paint lockers. All fire protection and associated sections are SOLAS excerpts however.	Only reference to vessels of less than 500 GT. All regulation/rules for over 500 GT is stated as "refer to SOLAS".	No specific section found in reference to paint lockers. All fire safety related matters are to meet SOLAS however.	Although no specific text could be found in LR main text, other references for special vessels are same as found in ABS. Societies other than ABS may not have specific references, but assumed to be uniformly covered by SOLAS regulations for fire extinguishing and personnel safety for storage spaces of flammable items.
671	CHAIN LOCKERS	See SWBS 581 - ANCHOR HANDLING & STOWAGE SYSTEM				
672	STOREROOMS & ISSUE ROOMS	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				
673	CARGO STOWAGE	Broad topic - need to address auxiliary section in rules for applicable vessel type				A broad topic that is mainly addressed on a vessel type to vessel type basis by the societies. Dependant upon the cargo, the cargo stowage requirements change. For "hazardous" cargoes, much of it is regulated by organizations such as IMO. Anytime regulation comes into play, the societies are very similar in their rules due to the regulation
690	***SPECIAL PURPOSE SYSTEMS***					Any dedicated, special service system or fluid not addressed in society main rules is subject to class approval from the society or surveyor
698	OUTFIT & FURNISHINGS OPERATING FLUIDS	Any "fluids" for shipboard use are contained in the propulsion of auxiliary sections of SWBS				Special fluids for outfit and furnishing are not covered by class rules. All fluids such as lube oil, fuel oil, hydraulic fluid are addressed in other SWBS numbers in the 200 and 500 sections, where the significant differences are very minimal
699	OUTFIT & FURNISHINGS PARTS & TOOLS	NOT APPLICABLE TO COMMERCIAL CLASSIFICATION SOCIETY SCOPE OF RULES				

SWBS	TOPIC	SOLAS *consolidated version LIFE SAVING EQUIPMENT				CFR *CFR 46 Shipping unless otherwise noted			
77	Evaluation, testing, approval of life-saving appl. and arrgmts	3.4				133.40	133.45	199.40	199.45
						199.190	160.001-3	28.140	
	Production Tests	3.5				160.001-5			
	Communications	3.6				133.60	199.60	28.245	32.02-5
						109.201	120.392	121.602	91.20/25
						92.10-45	97.15-3	97.37-5/7	108.595
	Two-way VHF radiotelephone	3.6.2.1	4.7/8/9	4.10	5.18	121.502/10	129.395	130.210	169.715
						183.392	91.60-20		
	EPIRB	3.6.2.2	4.7/8/9	4.10		117.64	180.64	199.510	161.011
						28.150	108.650	122.726/8	169.555
77	Distress Flares	3.6.3	5.9			131.890	47CFR80	133.60	
						117.68	180.68	160.028	160.066
						160.072	161.013	28.145	122.614
						169.553			
77	Rocket Parachute Flares		3.35			160.024	160.036		
77	Hand Flares		3.36			160.021	160.023fs	160.037	
77	Buoyant Smoke Signals		3.37			160.022	160.057		
	On-board communications and alarm systems General Alarm	3.6.4	2-2.40		3.5	28.240	35.40-1/5	113.25	120.550
						183.550	196.37-5/7	96.05	109.201
						108.625	97.37-5/7	121.602	
	Public address systems	3.6.5	2-2.40			78.17-51	113.50	121.610	96.05
						112.15-1			
77	Personal Life-Saving Appliances	3.7	3.21	3.27	3.30	133.70	199.70	199.176m	199.178s
						160.049	160.064	160.076/7	78.47-45
						28.105	28.135	108.580	108.645
						169.539/45	188.27	189.25-15	90.27
						108.500	96.06-1		
77	Lifebuoys	3.7.1	3.21.1	3.27.1	3.31	117.70	180.70	199.211	199.271
						160.050	28.115	108.649	169.513
						169.549	117.175e	117.200	
77	Lifejackets	3.7.2	3.21.2	3.24-1.5	3.32	117.71/5	117.78s	180.71/2	180.78s
						199.212	160.001	160.002	160.005
						160.006-2r	160.048	160.052	160.055
						160.060	160.176	28.110	108.649
						122.508	91.25-15	107.231	109.334
						115.808			
77	Lifejacket Lights		3.21.3	3.27.2	3.32.3	117.75	180.75	161.012	
77	Immersion Suits	3.7.3	3.21.4	3.27.3	3.33	199.214	199.273	160.171	108.649
						169.551			
77	Thermal Protective Aids		3.21.4	3.27.3	3.34	199.214	160.174		
88	Muster List and Emergency Instructions	3.8			3.53	133.80	199.80	199.217	78.13-1
						28.270	97.13-1	108.901	122.510
						196.13-1	97.15-35		
88	Operating Instructions	3.9				133.90	199.90		
88	Manning of Survival Craft and Supervision	3.10				199.100	109.323	169.819	
583	Survival Craft Muster and Embarkation Arrangements	3.11	3.22	3.28		117.150	133.110	180.150	199.110
						199.220	199.245	199.280	108.540
583	Launching Stations	3.12	3.24			133.120	199.120	199.240m	28.395
						108.633	110.15-1	114.400	116.500
583	Stowage of Survival Craft	3.13				117.130	117.137	133.130	180.130
						180.137	199.130	199.230	199.290
						28.125	108.530	108.646	169.521
583	Stowage of Liferafts		3.23	3.29		169.521			
583	Stowage of Rescue Boats	3.14				133.140	199.140	108.565	108.646
						169.521			
583	Survival Craft launching and recovery arrangements	3.15		3.28	3.48	133.150	199.150	199.245	28.310
						108.550			

SWBS	TOPIC	SOLAS *consolidated version				CFR *CFR 46 Shipping unless otherwise noted			
		LIFE SAVING EQUIPMENT							
583	Launching appliances using Falls and a Winch				3.48.2	133.153	199.153	160.015	160.032
						160.033	108.553	120.520	129.510
						183.520	96.05-1	111.95	114.400
						122.704			
583	Rescue Boat Embarkation, Launching, and recovery arrangements	3.16	3.22			133.160	199.160	199.22	108.570
583	Line-throwing appliances	3.17			3.49	133.170	199.170	160.031	160.040
						108.597			
88	Emergency training and drills	3.18	3.18.4	3.25		199.180	78.17-50	97.15-35	109.213
						122.520	185.520	196.15-35	199.250
						122.410	131.530		
88	Manuals	3.18.2			3.51				
88	On-board training and instructions	3.18.4			3.52				
	Records	3.18.5				97.35-3	109.433		
583	Survival Craft	3.20.1	3.26.1			117.175e	117.200-8	133.105	133.175e
						180.175e	180.200-8	199.175e	199.201
						199.261	160.010	160.027	28.120/130
						108.520/5	108.575e	169.513	169..535/7e
						189.25-15	91.20/25	90.30-5	112.43-7/11
						111.75-16	111.79-9/11	115.808	122.518
						122.730	114.400		
583	Liferafts		3.24-1.2	3.38		160.013e	160.042	169.531e	189.25-15
						108.655	109.323	117.130/50	117.175/200
						120.434	122.518		
583	Inflatable Liferafts			3.39		160.051	160.054e	60.151-Sola	108.647
						122.730	169.513	91.25-15	
583	Rigid Liferafts			3.40					
583	Rescue Boats	3.20.2	3.24-1.3	3.26.2	3.47	117.210	133.135	133.175e	180.210
						199.175e	199.202	199.262	108.560
						108.575e	169.517	189.25-20	131.580
583	Marshalling of Liferafts	3.20.3							
583	Lifeboats			3.41		199.203			
						199.520	160.013e	160.032e	160.033e
						160.035	160.044e	161.006e	169.513
						169.527/9e	189.25-20	92.10-40	90.10-20
						120.434	134		
583	Partially Enclosed Lifeboats			3.42					
583	Self-Righting partially enclosed lifeboats			3.43					
583	Totally enclosed lifeboats			3.44					
583	Free-fall Lifeboats			3.44.6	3.48.4	108.557	199.157		
583	Lifeboats with a self-contained air support system			3.45					
583	Fire-protected Lifeboats			3.46					
583	Lifeboat launching and recovery arrangements					199.155	160.015	108.555	
583	Float-free Launching			3.48.3		160.073l	114.400		
583	Evacuation-slide Launching			3.48.5		133.145	108.545	199.145	
583	Liferaft Launching Appliances			3.48.6					
583	Embarkation Ladders			3.48.7		160.017	92.10-15		
77	Safety Flame Lamps	5.11				160.016	77.30-5	167.45-60	
77	Emergency Drinking Water					160.026			
77	Magazine Chest					160.038	78.47-70	97.37-47	196.37-47
						108.651			
77	First Aid Kit					160.041	28.210	108.707	121.710
						169.725			
77	Jackknife					160.043			
77	Desalter Kit					160.058			
77	Fishing Tackle Kits					160.061			
583	Manual/Hydraulic releases for lifesaving equipment	5.19.9				160.062	28.405	28.880	122.740
						115.808			
		FIRE SAFETY SYSTEM							
521	Fire pumps, fire mains, hydrants and hoses	2-2.4				76.05-15	78.47	28.315	28.820
						34.05-1	34.10	95.05-5	95.10
						108.401	109.329/33	167.45-25	193.05-5
						193.10	132.A		

SWBS	TOPIC	SOLAS *consolidated version LIFE SAVING EQUIPMENT				CFR *CFR 46 Shipping unless otherwise noted			
521	Capacity of fire pumps	2-2.4.2				34.10-5	95.10-5	108.415	118.300
						132.120	169.559	181.300	193.10-5
521	Arrangements of fire pumps and of fire mains	2-2.4.3				76.10-5	34.10-5	95.10-5	108.417
						108.421	95.17-25	105.35-5/10	112.15-5
521	Diameter of, and pressure in, the fire mains	2-2.4.4				34.10	76.10	108.419	118.310
						169.561			
521	Number and position of hydrants	2-2.4.5				34.10-10	76.10-10	95.10-10	108.423
						118.310	95.17-25		
521	Pipes and hydrants	2-2.4.6				76.10-10	76.10-15	34.10-10	95.10-10
						95.10-15	97.37-15	132.110	167.45-15
						181.310	93.10-10/15	108.423	
521	Fire hoses	2-2.4.7				76.10-10	78.47-20	34.10-10	35.40-15
						95.10-10	108.425	118.320	167.45-10
						169.563	181.320	193.10-10	196.37-15
						107.257	109.331	91.25-20	105.35-15
						97.37-15	131.830		
521	Nozzles	2-2.4.8				76.10-10	118.320	181.320	95.10
						95.17-25			
555	Fixed gas fire-extinguishing systems	2-2.5				76.05-20	28.320	34.05-5	95.05-10
						97.37-10/13	108.403	108.631	118.410/20
						169.564	181.410/20	189.25-20	193.05-10
						196.37-10/13	105.35	91.20/25	131.815
555	Carbon dioxide systems	2-2.5.2				76.15	78.47-9	34.15	35.40-7
						35.40-10	95.15	97.37-9	108.431/57
						108.627	167.45-1/45	169.565	193.15
						196.37-9	118.400/41	115.810	122.612
						119.465			
555	Halogenated hydrocarbon systems	2-2.5.3				108.458	115.810	118.410/20	167.45-1
555	Steam systems	2-2.5.4				76.13	34.13	35.40-10	95.13
						167.45-1/5			
555	Fire extinguishers	2-2.6				76.05-25	76.50	78.47-30	28.160
						34.05-10	34.50	35.40-25	95.05-15
						95.50	97.37-23	108.637	118.500/20
						132.210/40	167.45-70	169.567	181.500/20
						189.25-20	193.05-15	193.50	196.37-25
						91.20/25	90.30	97.15-60	97.37-23
						115.810	118.410	126.450	
555	Fire-extinguishing arrangements in machinery spaces	2-2.7				95.05			
555	Spaces containing internal combustion machinery	2-2.7.2				95.05-10	116.620	119.465/70	
555	Spaces containing steam turbines or enclosed steam engine	2-2.7.3				28.340	95.05-10		
555	Fire extinguishing appliances in other machinery spaces	2-2.7.4				167.45-75	95.05-10	92.15-10	
555	Machinery spaces of cat. A in passenger ships	2-2.7.6				32.56-25/30	32.56-40		
555	Fixed deck foam systems	2-2.61				76.17	34.20	35.40-10/17	95.17
						108.459/77	95.05-10		
555	Fixed low-expansion foam fire-extinguishing systems in M.S.	2-2.8				76.17	34.17	35.40-1017	95.17
						108.459/77	167.45-50	91.25-20	95.05-10
555	Fixed high-expansion foam fire-extinguishing system in M.S.	2-2.9				76.17	34.17	35.40-10/17	95.17
						108.459/77	167.45-50	91.25-20	95.05-10
555	Fixed pressure water-spraying fire-extinguishing systems in MS	2-2.10				34.25	35.40-18		
555	Special arrangements in MS	2-2.11							
	Manual Sprinkling System					76.23	113.20	118.400	
522	Automatic sprinkler, fire detection and fire alarm systems	2-2.12	2-2.36/52			76.25	78.47-13	34.30	95.30
						108.430	133.20	193.15	113.20
						112.15-5			
77	Supervised patrol system					76.05-10	78.47-23	95.05-1	193.05-1
	Manual alarm system	2-2.2.1				76.05-5	76.35	78.47-10	95.05-1
						193.05-1	113.1		
527	Fixed fire detection and fire alarm systems	2-2.13	2-2.36/52			76.05-1	76.27e	76.30p	78.47-5/7
						28.240	28.325	28.830	95.05-1

SWBS	TOPIC	SOLAS *consolidated version LIFE SAVING EQUIPMENT				CFR *CFR 46 Shipping unless otherwise noted			
						108.404/5	108.407e	108.407p	113.10
						113.25	193.05-1	96.05-1	112.15-1
	Installation req.	2-2.13.2				130.470			
	Design req.	2-2.13.3							
527	Sample extraction smoke detection systems	2-2.13-1				76.33	78.17-65	108.411	113.10
						181.450	112.15-1		
	Installation req.	2-2.13-1.2							
	Design req.	2-2.13-1.3							
527	Fixed fire detection and alarm system for unattended MS	2-2.14	2-1.47/51			133.10	130.440/80		
555	Fixed fire-extinguishing arrangement in cargo spaces	2-2.39	2-2.53			28.885	132.310	95.05	
	Oil fuel, lube. oil, and other flammable oils	2-2.15				78.17-75	28.335	28.835	35.30-40
						97.15-55	95.05-10		
	Limitations in the use of oil as fuel	2-2.15.1				167.45-40	196.15-55		
	Oil fuel arrangements	2-2.15.2				78.17-75	196.15-55	95.05-55	
	Lubricating Oil arrangements	2-2.15.3							
	Other flammable oil arrangements	2-2.15.4							
	Periodically unattended MS	2-2.15.5							
	Prohibition of flammable oils in forepeak tanks	2-2.15.6							
527	Ventilation systems	2-2.16	2-2.32	2-2.48	2-2.59	78.47-53	28.340	32.55	92.15
						97.37-50	108.181/7	169.315	177.600
						190.15	95.05-10	97.37-50	133.105
						111.103	111.33	116.600/20	119.465/70
77	Fireman's Outfit	2-2.17				77.35	77.30-5	28.205	96.35
						108.497	109.337	169.717	195.35
	Miscellaneous Items	2-2.18				181.610			
	International shore connection	2-2.19				108.427	120.390	129.390	111.83
88	Fire control plans and drills	2-2.20				78.17-50	122.524	169.833	185.524
						109.213	116.530	131.535	
77	Means of escape	2-2.28	2-2.45			28.390	32.02-1	92.10	108.151/9
						108.160/7	127.240	169.313	177.500
						190.10	91.60	116.500	114.400
	Restricted use of combustible material	2-2.34	2-2.49			38	108.123	108.127	90.05-35
						109.557			
	Inert gas systems	2-2.62							
	Fire Axes					76.60	34.05-20	34.60	95.60
						108.499	109.339	118.600	132.360
						167.45-80	169.569	181.600	193.60
						131.880			
	Self contained breathing apparatus					78.47-27	28.205	97.37-20	108.635
						167.45-60	195.30-15	196.37-20	96.03-1
						96.35	96.30-5/15		
	Emergency squad equipment					78.47-25	78.17-80	28.155	35.30-20
						35.40-20	97.15-60	109.223	167.45-30
						196.15-60	97.37	110.15-1	113.30-5
						131.590			
	Emergency Lighting/Light Searchlight					78.17-45	78.47-33	34.40-6	97.15-30
						97.37-25	108.639	109.211	120.432
						129.440	169.711	183.432	196.15-30
						96.05	92.05-15	97.25	112
						111.75			
	Fire doors	2-2.47				87.47-35	32.56-35	111.99	112.15-1
	Watertight doors					78.17-3	78.47-37	97.37-90	122.610
						91.25-25	97.15-20	111.97	115.402
						119.500	122.330		
	Fire Safety Measures - structure	2-2.23	2-2.42			28.385	32.56	32.57	92.07
						108.131/3	169.311	177.405/10	190.05
						92.05	91.25-45	108.123/7	116.430

SWBS	TOPIC	SOLAS *consolidated version LIFE SAVING EQUIPMENT				CFR *CFR 46 Shipping unless otherwise noted			
	Main vertical zones and horizontal zones	2-2.24	2-2.56			116.415	114.400		
	Bulkheads within a main vertical zone	2-2.25	2-2.43	2-2.57		114.400			
	Fire integrity of bulkheads and decks	2-2.26/27	2-2.44	2-2.58		92.05	108.135/9	108.141	
	Protection of stairways and lifts in accommodation and service space	2-2.29	2-2.46			108.143	112.15-1		
	Window and side-scuttles	2-2.33				116.433			
555	Protection of special category spaces	2-2.37	2-2.38	2-2.60		105.35	167.45-65	110.15-1	116.600
	Cargo pump-rooms	2-2.63				32.60-20			
	Details of construction	2-2.35	2-2.50			110.15-1			
	Special req. for ships carrying dangerous food	2-2.54							
	Steering gear	5.19-2	5.19-1			96.05	122.320	113.30-5	
	Engine Order Telegraph					96.05	113.35	129.560	
	Sounding					96.27			
	Fire Watch					97.27-5			
	Marine evaluation system					108.545			
	Lifesaving signals					97.43			
	National Fire Protection Assoc.					107.115	110.10-1	114.600	121.200
	Sound-powered telephone					121.240 96.05-1	133.20-25	113.30	
	Work Vests					97.34	108.636	108.697/9	109.334
	Engineers Assistance needed					117.72 113.27	131.170		
	Steering failure alarm					133.43			
	Emergency generator					112.50-1/5	111.12		
	Emergency diesel and gas turbine					112.20-10	112.25		
	Emergency battery charger					112.55-10			
	Emergency Bus Tie					112.05-3			
	Mooring Equipment					121.300			
	Towing	5.15-1							

SWBS	TITLE	SOLAS	CFR	DIFFERENCE	
79	Floodable Length Passenger Vessels	II-1.4	171.017	SOLAS:	Calculations consider form, draught, and other characteristics If have continuous bulkhead: the maximum portion of the ship, having its center at the point in question, which can be flooded without the ship being submerged beyond the margin line. If no continuous bulkhead: assumed continuous margin line which at no point is less than 76mm below the top of the deck (at side) to which the bulkheads concerned and the shell are carried watertight If assumed margin line is below the deck to which bulkheads are carried, a limited relaxation in the watertightness of those portions of the bulkheads which are above the margin line and immediately under the higher deck.
			171.065		
			171.070		
			171.075		
				CFR:	Design to a one compartment standard of flooding in the margin line is not submerged when the total buoyancy between each set of two adjacent main transverse watertight bulkheads is lost. Design to a two compartment standard of flooding if the margin line is not submerged when the total buoyancy between each set of the three adjacent main transverse watertight bulkheads is lost. In accordance with IMO Resolution A.256 (VIII)
79	Permeability	II-1.5	170.055	BOTH:	SOLAS and CFR's have the same requirements for permeability However, SOLAS has an additional calculation for unusual arrangements,
			171.066/8		
			171.072	SOLAS:	Permeability (avg. in percent) = 95-35(b/v) where: (b) = the volume of space below the margin line above the tops of floors, double bottoms, etc. and (v) = the whole volume of the ship below the margin line
			171.080		
	Subdivision - factors	II-1.6	171.060		
		II-1.7	171.065		
			171.070		
			171.075		
			171sbprt.D		
	Stability in damaged condition	II-1.8	171.080/2		
			171.145		
			171.150		
	Ballasting (water)	II-1.9			
	Peak and machinery space - bulkheads, shaft tunnels, etc.	II-1.10	171.095		
		II-1.11	171.100		
	Double Bottoms	II-1.12	171.105	BOTH:	In vessels, 50 - 61 m in LBP, a double bottom shall be fitted at least from the machinery space to the forepeak bulkhead. 61 - 76 m in LBP, a double bottom shall be fitted at least outside the machinery space, and shall extend to the fore and after peak bulkheads. 76 m and upwards in LBP, a double bottom shall be fitted amidships, and shall extend to the fore and after peak bulkheads. The line formed by the intersection of the margin plating and the bilge plating is not lower at any part than a horizontal plane passing through the point of intersection with the frame line amidships of a transverse diagonal line inclined at 25 degrees to the base line and cutting it at a point one half the ship's moulded breadth from the middle line. A double bottom is not required in any part of a vessel where the separation of main transverse watertight bulkheads is governed by a factor of subdivision of less than or equal to 0.50 if the vessel makes short international voyages, or carries a number of passengers in excess of the lifeboat capacity.
		II-1.12-1			
			171.108/9		
				SOLAS:	A double bottom need not be fitted in way of watertight compartments of moderate size used exclusively for the carriage of liquids, provided the safety of the ship, in the event of bottom or side damage, is not thereby impaired.
				CFR:	Each double bottom must be at least the depth at the centerline given by the depth at the centerline given by the following equations: D=18.0+0.05(L) inches and D=45.7+0.417(L) centimeters where D=the depth at the centerline, and L=LBP

SWBS	TITLE	SOLAS	CFR	DIFFERENCE	
	Double Bottom, Wells	II-1.12	171.106	BOTH:	The well may not extend below the horizontal plane. A well may extend to the outer bottom of a double bottom at the after end of a shaft tunnel.
				SOLAS:	The depth of the well shall in no case be more than the depth less 460mm of the double bottom at the centerline.
				CFR:	The depth of a well must be at least 18 inches (45.7cm) less than the depth of the double bottom at the centerline.
	Assigning, marking, and recording of subdivision load lines	II-1.13	171.116/8 171.080(a)		
	Watertight bulkheads	II-1.14 II-1.15	171.065-8 171.070-3		
	Openings in the shell plating below the margin line	II-1.17	171.111 171.113		
79	Watertight integrity above the margin line	II-1.20	171 sbprtG	BOTH:	Same requirements for openings in an exposed weatherdeck. Openings must have coamings of ample height and strength, and have a means for closing it weathertight.
				SOLAS:	When partial bulkheads or webs are fitted in the bulkhead deck, above or in the immediate vicinity of main subdivision bulkheads, they shall have watertight shell and bulkhead deck connections so as to restrict the flow of water along the deck when the ship is in a heeled damaged condition. Where it does not line up with the bulkhead below, the bulkhead deck between shall be made effectively watertight. The bulkhead deck or deck above shall be weathertight. Freeing ports, open rails, and scuppers shall be fitted as necessary. Air pipes terminating within the superstructure hall be as least 1m above the waterline when the ship heels 15 degrees as the maximum angle of heel during intermediate stages of flooding.
				CFR:	Partial watertight bulkhead or web frame is located in the immediate vicinity of the main transverse watertight bulkheads to minimize as much as practicable the entry and spread of water above the bulkhead deck. If located on the bulkhead deck the joint between it and the shell and bulkhead deck must be watertight. Each port light located between the bulkhead deck and the next deck must have an inside dead cover than can be secured watertight. CFR's also give stringent requirements about weathertight hatches in a vessel less than 100 gross tons.
	Bilge pumping arrangements	II-1.21	56.50-50	BOTH:	
				SOLAS:	Bilge main diameter, d=25+1.68 sq.root (L(B+D)) where (d)= the inner diameter in millimeters, (L) and (B) are the length and the breadth of the ship in meters, and (D) = the molded depth to the bulkhead deck in meters.
				CFR:	d=1+sq.rt.((L(B+D))/2500) where L = the length of the vessel on load water line in feet (B) = the breadth of the vessel in feet and (D) = the molded depth to the bulkhead deck in feet.
	Damage control	II-1.23			
	Marking, operation and inspection of watertight doors	II-1.24	122.610 78.17-3 78.17-5	BOTH:	It shall be the duty of the master to see that all watertight doors in subdivision bulkheads that may be opened at sea, and all mechanisms, remote controls, and indicators connected therewith, shall be periodically inspected at least once a week. On vessels in which the voyage that exceeds one week in duration, these doors shall be operated before the vessel leaves port. All such doors shall be operated daily. All valves, including cross connecting valves where fitted, and other appliances such as port lights, closing mechanism of scuppers, ash chutes, and rubbish chutes, the closing of which is necessary to make a compartment watertight, are operated at least once in every week that the vessel is navigated to be assured that they are in proper operating condition.
				SOLAS:	In addition to the above, SOLAS specifically requires the above for all vessels and the markings of all such valves, doors and mechanisms shall be suitably marked to ensure that they be properly used to provide maximum safety.
				CFR:	In addition to the above, watertight door markings are more stringent, all watertight doors must be marked, "WATERTIGHT DOOR - KEEP CLOSED". Letters must be at least 25millimeters (1 inch) high and clearly visible.

SWBS	TITLE	SOLAS	CFR	DIFFERENCE	
	Means of going astern	II-1.28	58.05-5	BOTH:	All vessels shall have sufficient power for going astern to secure proper control of the ship in normal circumstances.
				SOLAS:	The ability of the machinery to reverse direction of thrust of the propeller in sufficient time, and to bring the ship to rest within a reasonable distance from maximum ahead speed. The stopping times, ship headings, and distances recorded on trials, together with the results of trials to determine the ability of ships having multiple propellers to navigate and maneuver with one or more propellers inoperative, shall be available on board for use of the master or designated personnel. Where the ship is provided with supplementary means for maneuvering or stopping, the effectiveness of such means shall be demonstrated and recorded.
	Steering Gear, general	II-1.29	58.25	BOTH:	Power operated main and auxiliary steering gear systems must be independent throughout their length. Requirements for the main steering gear system: rudder stock diameter, angle movement and time limit are the same. Auxiliary steering gear requirements of rudder stock diameter, angle movement, and time limit are the same. When the main steering gear includes two or more identical power units, no auxiliary steering gear need to be fitted. In a vessel of 70,000 gross tons or over, the main steering gear must have two or more identical power units.
	Steering gear, voice communications	II-1.29	58.25-15	BOTH:	Require a means of communication between the pilot house, machinery space, and steering gear compartment.
				CFR:	This means of communication must be with a sound-powered telephone system.
	Steering gear, Piping for	II-1.29	58.25-20	BOTH:	Relief valves must be fitted in any part of a hydraulic system that can be isolated and in which pressure can be generated from the power units or from external forces. The valves must be of adequate size and must be set to limit the maximum pressure to which the system may be exposed. Each hydraulic system must be provided with arrangements to maintain the cleanliness of the hydraulic fluid (appropriate to the type and design of the system). Each hydraulic system with a fixed storage tank, must have sufficient capacity to recharge at least one power actuating system including the reservoir. The storage tank must be permanently connected to the piping so that the hydraulic system can be readily recharged from within the steering gear compartment and must be fitted with a device to indicate the liquid level.
				SOLAS:	All steering gear components and the rudder stock shall be of sound and reliable construction. Special consideration shall be given to the suitability of any essential component not duplicated. Any essential component shall utilize antifriction bearings such as ball-bearings, roller-bearings, or sleeve-bearings which shall be permanently lubricated or provided with lubrication fittings.
				CFR:	Neither a split flange nor a flareless fitting of the grip or bite type may be used in hydraulic piping for steering gear.
	Steering gear: Automatic Restart	II-1.29	58.25-30	BOTH:	Each control system for main and auxiliary steering gear and each power actuating system must restart automatically when electrical power is restored after it has failed.
	Steering gear: Indicating & alarm sys.	II-1.29	58.25-25	BOTH:	Indication of the rudder angle must be provided both at the main steering station in the pilot house and in the steering gear compartment. The rudder indicator must be independent of control systems for steering gear. An audible and visual alarm must activate in the pilothouse upon: failure of the electric power to control system of any steering gear, failure of that power to the power unit of any steering gear, and the occurrence if a low oil level in any oil reservoir of a hydraulic, power operated steering gear system. An audible and a visible alarm must activate in the machinery space upon the occurrence of low oil level in any oil reservoir of the hydraulic system.
				SOLAS:	Each electric-type rudder angle indicator much draw its power from the emergency source or from a private source located within the steering gear compartment. This private source will only be used for this purpose.
				CFR:	Each electric-type rudder-angle indicator will draw its power form the source of emergency power. An audible and visible alarm will activate in the machinery space also upon failure of any phase of a three phase power supply, and overload of any motor.
	Steering gear: Helm Arrangements		58.25-35	CFR only:	The arrangement of each steering station, other than in the steering gear compartment, must be such that the helmsman is abaft the wheel. The rim of the wheel must be plainly marked with arrows and lettering for right abd left rudder, or a suitable notice indicating these directions must be posted directly in the helmsman's line of sight. Each steering wheel must turn clockwise for "right rudder" and counterclockwise for "left rudder". When the vessel is running ahead, after clockwise movement of the wheel the vessel's heading must change to the right. If a lever-type control is provided, it must be installed and marked so that its movement clearly indicates both the direction of the rudder's movement, and, if follow-up control is also provided, the amount of the rudder's movement. Markings in the pilothouse must not interfere with the helmsman's vision, but must be clearly visible at night.
	Steering gear: arrangem of the compartment	II-1.29	58.25-40	BOTH:	The steering gear compartment must be readily accessible and, as far as practicable, separated from any machinery space, ensure working access to machinery and controls in the compartment, and include handrails and gratings or other non-

SWBS	TITLE	SOLAS	CFR	DIFFERENCE	
					slip surfaces to ensure a safe working environment if hydraulic fluid leaks.
	Steering gear: Buffers		58.25-45	CFR only:	Steering gear other than hydraulic must be designed with suitable buffering arrangements to relieve the gear from shocks to the rudder.
	Steering gear: rudder stops		58.25-50	CFR only:	Power-operated steering gear must have arrangements for cutting off power to the gear before the rudder reaches the stops. These must be synchronized with the rudder stock or with the gear itself rather than be within the control system for the steering gear, and must work by limit switches that interrupt output of the control system or by other means. Strong and effective structural rudder stops must be fitted; except that, where adequate positive stops are provided within the steering gear, such structural stops need not be fitted.
	Steering gear: Overcurrent Protection	II-1.29 II-1.30	58.25-55		
	Electric/electro - hydraulic steering gear	II-1.30			
	Machinery Control	II-1.31	62.25 62.35 62.50		
	Steam Boilers and Boiler feed systems	II-1.32	52 56.50-30 61.05-10		
	Steam Pipe Systems	II-1.33	56.50-15 61.15-5	SOLAS:	Every steam pipe and every fitting connected thereto through which steam may pass shall be so designed, constructed, and installed as to withstand the maximum working stresses to which it may be subjected. Means shall be provided for draining every steam pipe in which dangerous water hammer action might otherwise occur. If a steam pipe of fitting may receive steam from any source at a higher pressure than that for which it is designed a suitable reducing valve, relief valve and pressure gauge shall be fitted.
				CFR:	Main steam piping shall be subjected to a hydrostatic test equal to 1 1/4 times the maximum allowable working pressure at the same pressure prescribed for boilers. Test applied from the boiler drum to the throttle valve, maintained for a period of 10 minutes. All steam piping subject from to pressure from the main boiler should be subjected to a hydrostatic test at a pressure of 1 1/4 times the maximum allowable working pressure of the boiler after every five years of service. Maintained for 10 minutes. No piping with a nominal size of 3 inches or less need to hydrostatically tested.
	Air Pressure Systems	II-1.34			
	Ventilating systems in machinery spaces	II-1.35	58.01-45	BOTH:	Each machinery space must be ventilated to ensure that, when machinery or boilers are operating at full power in all weather including heavy weather, an adequate supply of air is maintained for the operation of the machinery and for the safety, efficiency, and comfort of the crew.
	Protection against noise	II-1.36	58.01-50	BOTH:	In accordance with IMO resolution A.468(XII), measures shall be taken to reduce machinery noise in machinery spaces to acceptable levels. If noise cannot be sufficiently reduced the source of excessive noise shall be suitably insolated or a refuge from noise shall be provided if the space is required to be manned. Ear protectors shall be provided for personnel required to enter such spaces.
				CFR:	Much more specific: No person may encounter a 24-hour effective noise level greater than 82 dB when noise is measured using a sound level meter and an A-weighting filter. No machinery space may exceed noise levels listed in part b.1,2,3,4,5,6. Each entrance to a machinery space with noise level greater than 85 dB must have a warning sign stating that each person entering the space must wear ear protection.
	Communication between navigation. Bridge and machinery space	II-1.37			

SWBS	TITLE	SOLAS	CFR	DIFFERENCE	
	Engineers Alarm	II-1.38	113.27-1	BOTH:	An engineer's alarm shall be provided to be operated from the engine control room or at the maneuvering platform as entering the entering the and shall be clearly audible in the engineers' accommodation spaces.
				CFR:	Vessel must have a manually operated engineer's assistance alarm that is powered from the general alarm power source.
	Main source of electrical power and lighting systems	II-1.41			
	Emergency source of electrical power	II-1.42	112.20		
	Starting arrangements for emergency generating sets	II-1.44	111.10		
			112.50-5		
	Precautions against shock, fire, and other hazards of electrical origin	II-1.45	111.101-1		
			111.50		
			111.105		
	Protection against flooding	II-1.48	171.017		
	Control of propulsion machinery from the navigation bridge	II-1.49	62.35-5		
			62.25		
			62.50		
	Alarm system	II-1.51	113.25		
			113.43-3		
	Safety system	II-1.52			

SHIP WORK BREAKDOWN STRUCTURE (GROUIPS 100-600)

100 HULL STRUCTURE, GENERAL

101 GENERAL ARRANGEMENTS - STRUCTURAL DRAWINGS
110 SHELL AND SUPPORTING STRUCTURE
111 SHELL PLATING, SURF. SHIP AND SUBMARINE PRESS. HULL
112 SHELL PLATING, SUBMARINE NON-PRESSURE HULL
113 INNER BOTTOM
114 SHELL APPENDAGES
115 STANCHIONS
116 LONGITUDINAL FRAMING
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118 LONGITUDINAL. AND TRANSVERSE. SUBMARINE NON-PRESS. HULL FRAMING
119 LIFT SYSTEM FLEXIBLE SKIRTS AND SEALS
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122 TRANS STRUCTURAL BULKHEADS
123 TRUNKS AND ENCLOSURES
124 BULKHEADS IN TORPEDO PROTECTION SYSTEM
125 SUBMARINE HARD TANKS
126 SUBMARINE SOFT TANKS
130 HULL DECKS
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134 4TH DECK
135 5TH DECK
136 01 HULL DECK (FORECASTLE AND P00P DECKS)
137 02 HULL DECK
138 03 HULL DECK
139 04 HULL DECK AND HULL DECKS ABOVE
140 HULL PLATFORMS AND FLATS
141 1ST PLATFORM
142 2ND PLATFORM
143 3RD PLATFORM
144 4TH PLATFORM
145 5TH PLATFORM
149 FLATS
150 DECK HOUSE STRUCTURE
151 DECKHOUSE - 1ST LEVEL 01 LEVEL
152 1ST DECKHOUSE LEVEL 02 LVL
153 2ND DECKHOUSE LEVEL 03 LVL
154 3RD DECKHOUSE LEVEL 04 LVL
155 4TH DECKHOUSE LEVEL 05 LVL
156 5TH DECKHOUSE LEVEL 06 LVL
157 6TH DECKHOUSE LEVEL
158 7TH DECKHOUSE LEVEL
159 8TH DECKHOUSE LEVEL
160 SPECIAL STRUCTURES
161 STRUCTURAL CASTINGS & FORGINGS

162 STACKS
163 SEA CHESTS
164 BALLISTIC PLATING
165 SONAR DOMES
166 SPONSORS
167 HULL STRUCTURAL CLOSURES
168 DECKHOUSE STRUCTURAL CLOSURES
169 SPECIAL PURPOSE CLOSURES
170 MASTS, KINGPOSTS, AND SERVICE PLATFORMS
171 MASTS TOWERS TETRAPODS
172 KINGPOSTS AND SUPPORT FRAMES
179 SERVICE PLATFORMS
180 FOUNDATIONS
181 HULL STRUCTURE FOUNDATIONS
182 PROPULSION PLANT FOUNDATIONS
183 ELECTRIC PLANT FDNS
184 COMMAND & SURVEILLANCE FDNS
185 AUXILIARY SYSTEMS FDNS
186 OUTFIT & FURNISHINGS FDNS
187 ARMAMENT FDNS
190 SPECIAL PURPOSE SYSTEMS
191 BALLAST FIXED LEAD
192 COMPARTMENT TESTING
195 ERECTION OF SUB SECTIONS (PROGRESS REPORT ONLY)
196 WELDS & MILL TOLERANCE
198 FREE FLOODING LIQUIDS
199 HULL REPAIR PARTS AND SPECIAL TOOLS

200 PROPULSION PLANT ,GENERAL

201 FINAL WEIGHT REPORT GROUP2
202 MACHINERY PLANT CENT CONTROL SYS
210 ENERGY GENERATING SYSTEM (NUCLEAR)
211 (RESERVED)
212 NUCLEAR SYSTEM GENERATOR
213 REACTORS
214 REACTOR COOLANT SYSTEM
215 REACTOR COOLANT SERVICE SYSTEM
216 REACTOR PLANT AUXILIARY SYSTEMS
217 NUCLEAR POWER CONTROL AND INSTRUMENTATION
218 RADIATION SHIELDING (PRIMARY)
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221 PROPULSION BOILERS
222 GAS GENERATORS
223 MAIN PROPULSION BATTERIES
224 MAIN PROPULSION FUEL CELLS
230 PROPULSION UNITS
231 PROPULSION STEAM TURBINES
232 PROPULSION STEAM ENGINES
233 PROPULSION INTERNAL COMBUSTION ENGINES
234 PROPULSION GAS TURBINES

235 ELECTRIC PROPULSION
236 SELF-CONTAINED PROPULSION SYSTEMS
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243 PROPULSION SHAFTING
244 PROPULSION SHAFT BEARINGS
245 PROPULSORS
246 PROPULSOR SHROUDS AND DUCTS
247 WATER JET PROPULSORS
248 LIFT SYSTEM FANS AND DUCTING
250 PROPULSION SUPPORT SYS. (EXCEPT FUEL AND LUBE OIL)
251 COMBUSTION AIR SYSTEM
252 PROPULSION CONTROL SYSTEM
253 MAIN STEAM PIPING SYSTEM
254 CONDENSERS AND AIR EJECTORS
255 FEED AND CONDENSATE SYSTEM
256 CIRCULATING & COOLING SW SYS
259 UPTAKES (INNER CASING)
260 PROPULSION SUPPORT SYSTEMS (FUEL AND LUBE OIL)
261 FUEL OIL SERVICE SYSTEM
262 MAIN PROPULSION LUBE OIL
263 SHAFT LUBE OIL SYSTEM (SUBMARINES)
264 LUBE OIL FILL TRANSFER & PURIFICATION
290 SPECIAL PURPOSE SYSTEMS
298 PROPULSION PLANT OPERATING FLUIDS
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300 ELECTRIC PLANT, GENERAL

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305 ELECTRICAL DESIGNATING AND MARKING
310 ELECTRIC POWER GENERATION
311 SHIP SERVICE POWER GENERATION
312 EMERGENCY GENERATORS
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400 COMMAND AND SURVEILLANCE, GENERAL

401 GENERAL ARRANGEMENT - COMMAND AND SURVEILLANCE
402 SECURITY REQUIREMENTS
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406 GROUNDING AND BONDING
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417 COMMAND AND CONTROL ANALOG SWITCHBOARDS
420 NAVIGATION SYSTEMS
421 NON-ELECTRICAL NAVIGATION AIDS
422 ELECTRICAL NAVIGATION AIDS
423 ELEX NAVIGATION SYS-RADIO
424 ELEX NAVIGATION SYS ACOUSTICAL
425 PERISCOPES
426 ELEC NAVIGATION SYSTEMS
427 INERTIAL NAVIGATION SYS
428 NAVIGATION CONTROL MONITORING
430 INTERIOR COMMUNICATIONS
431 SWITCHBOARDS FOR IC SYSTEMS
432 TELEPHONE SYSTEMS
433 ANNOUNCING SYSTEMS
434 ENTERTAINMENT & TRAINING SYS
435 VOICE TUBES & MESSAGE PASS SYS
436 ALARM SAFETY & WARNING SYS
437 INDICATING ORDER & METERING SYS
438 INTEGRATED CONTROL SYSTEMS
439 RECORDING & TV SYSTEMS
440 EXTERIOR COMMUNICATIONS
441 RADIO SYSTEMS
442 UNDERWATER COMM SYSTEMS
443 VISUAL & AUDIBLE SYSTEMS
444 TELEMETRY SYSTEMS
445 TTY & FACSIMILE SYSTEMS
446 SECURITY EQUIPMENT
450 SURVEILLANCE SYSTEMS (SURFACE)
451 SURFACE SEARCH RADAR

452 AIR SEARCH RADAR (2D)
453 AIR SEARCH RADAR (3D)
454 AIRCRAFT CONTROL APPROACH RADAR
455 IDENTIFICATION SYS (IFF)
456 MULTIPLE MODE/FUNCTION RADAR
459 SPACE VEHICLE ELECTRONIC TRACKING
460 SURVEILLANCE SYSTEMS (UNDERWATER)
461 ACTIVE SONAR
462 TORPEDO DETECTION SYS
463 MULTIPLE MODE SONAR
464 CLASSIFICATION SONAR
465 BATHYTHERMOGRAPH
470 COUNTERMEASURES
471 ACTIVE EM (INCL. COMBINATION ACTIVE/PASSIVE)
472 PASSIVE ECM
473 TORPEDO DECOYS
474 DECOYS
475 DEGAUSSING
476 MINE COUNTERMEASURES
480 FIRE CONTROL SYSTEMS
481 GUN FIRE CONTROL SYSTEMS
482 MISSILE FIRE CONTROL SYS
483 FIRE CONTROL SYS UNDERWATER
484 INTEGRATED FIRE CONTROL SYS
489 FIRE CONTROL SWITCHBOARDS
490 SPECIAL PURPOSE SYSTEMS
491 ELECTRONIC TEST CHECK MONITOR SYS
492 FLIGHT CONTROL AND INSTRUMENT LANDING SYSTEMS
493 NON COMBAT DATA PROCESS
494 METEOROLOGICAL SYSTEMS
495 SPECIAL INTELLIGENCE SYS
496 CRYPTOLOGIC COMBAT SUPPORT SYS
498 COMMAND & SURVEILLANCE OPER FLUIDS
499 COMMAND & SURVEIL SPARES & TOOLS

500 AUXILIARY SYSTEMS, GENERAL

501 GENERAL ARRANGEMENTS - AUXILIARY SYSTEMS DRAWINGS
502 AUXILIARY MACHINERY
503 PUMPS
504 INSTRUMENTS AND INSTRUMENT BOARDS
505 GENERAL PIPING REQUIREMENTS
506 OVERFLOWS, AIR ESCAPES, AND SOUNDING TUBES
507 AUXILIARY AND PIP DESIG AND MARK
508 THERMAL INS FOR PIP AND MACH
509 THERMAL INSULATION FOR VENT AND A/C DUCTS
510 CLIMATE CONTROL
511 COMPARTMENT HEATING SYSTEMS
512 VENTILATION SYSTEM
513 MACHINERY SPACE VENTILATION SYS
514 AIR CONDITIONING SYSTEM
515 AIR REVITALIZATION SYSTEMS (SUBMARINES)

516 REFRIGERATION SYSTEM
517 WASTE HEAT BOILER SYSTEM
520 SEA WATER SYSTEMS
521 FIREMAIN & SW FLUSHING SYS
522 SPRINKLER SYSTEM
523 WASHDOWN SYSTEM
524 AUXILIARY SEAWATER SYSTEM
526 SCUPPERS & DECK DRAINS
527 FIREMAN ACTUATED SERVICES - OTHER
528 PLUMBING DRAINAGE
529 DRAINAGE & BALLASTING SYS
530 FRESH WATER SYSTEMS
531 DISTILLING PLANT
532 COOLING WATER
533 POTABLE WATER
534 AUXILIARY STEAM SYS - MACHINERY SPACE
541 SHIP FUEL & COMPENSATING SYS
542 AVIATION & GENERAL PURPOSE FUEL SYS
543 AVIATION AND GEN PURPOSE LUBE OIL
544 LIQUID CARGO
545 TANK HEATING
549 SPECIAL FUEL AND LUBRICANTS, HANDLING AND STOWAGE
550 AIR GAS AND MISC. FLUID SYSTEMS
551 COMPRESSED AIR SYSTEMS
552 COMPRESSED GASES N2
553 O2 SYSTEMS
554 LP BLOW
555 FIRE EXTINGUISHING SYSTEM
556 HYDRAULIC FLUID SYSTEM
557 LIQUID GASES, CARGO
558 SPECIAL PIPING SYSTEMS
560 SHIP CONTROL SYSTEMS
561 STEERING CONTROL SYSTEMS
562 RUDDERS
563 HOVERING AND DEPTH CONTROL (SUBMARINE)
564 TRIM SYSTEM (SUBMARINES)
565 TRIM AND HEEL SYSTEMS
566 DIVING PLANES AND STABILIZING FINS (SUBMARINES)
567 STRUT AND FOIL SYSTEMS
568 MANEUVERING SYSTEMS
571 REPLENISHMENT AT SEA SYS
572 STORES HANDLING SYSTEMS
573 CARGO HANDLING SYSTEMS
575 VEHICLE HANDLING AND STOWAGE SYSTEMS
580 MECHANICAL HANDLING SYSTEMS
581 ANCHOR HANDLING & STOWAGE SYS
582 MOORING & TOWING SYSTEMS
583 BOAT HANDLING & STOWAGE SYS
584 LANDING CRAFT HANDLING AND STOWAGE SYSTEMS
585 ELEVATING AND RETRACTING GEAR

586 AIRCRAFT RECOVERY SUPPORT SYS
587 AIRCRAFT LAUNCH SUPPORT SYSTEMS
588 HELO HANDLING SERVICE & STOWAGE
589 MISC. MECHANICAL HANDLING SYS
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591 SCIENTIFIC AND OCEAN ENGINEERING SYSTEMS
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594 SUBMARINE RESCUE, SALVAGE, AND SURVIVAL SYSTEMS
595 TOWING, LAUNCH & HDLG UNDERWATER
596 HANDLING SYS. FOR DIVER AND SUBMERSIBLE VEHICLES
597 SALVAGE SUPPORT SYSTEMS
598 AUXILIARY SYS OPERATING FLUIDS
599 AUXILIARY SYS REPAIR PARTS & TOOLS

600 OUTFIT AND FURNISHINGS

601 FINAL WEIGHT REPORT GROUP6
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603 DRAFT MARKS
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673 CARGO STOWAGE
690 SPECIAL PURPOSE SYSTEMS
698 OUTFIT & FURN OPER FLUIDS
699 OUTFIT & FURN PARTS & TOOLS

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